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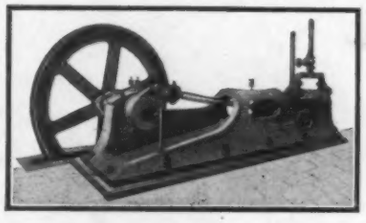

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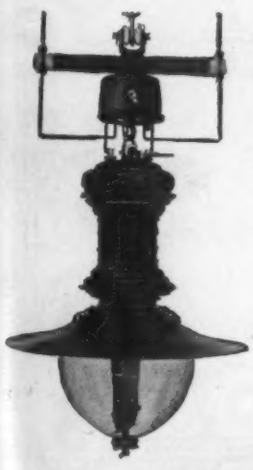

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The Journal of Electricity, Power and Gas.

Devoted to the Conversion, Transmission and Distribution of Energy.

VOLUME XIII. SAN FRANCISCO, CAL., SEPTEMBER, 1903. NUMBER 8

The Seventh Annual Convention of the Pacific Coast Electric Transmission Association.

Continuation of the Interesting Papers Contributed by Prominent Engineers and Read Before the Convention at San Rafael.—Unofficial

TANGENTIAL WATER WHEEL EFFICIENCIES.

BY GEORGE J. HENRY, JR.

IT is not the writer's intention to attempt to determine the equation for the so-called true hydraulic curve, or to exhibit new and improved bucket shapes which will greatly increase the efficiency of a water wheel, but rather to discuss some of the well known shapes of buckets and particularly the ellipsoidal as compared with the general form of the Pelton bucket.

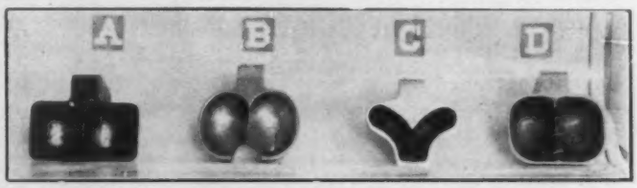
The conclusions arrived at are not theories deduced entirely on paper, but are the result of a very elaborate series of experiments carried out since 1899 in the special laboratory of the Pelton Water Wheel Company with a view to scientifically and practically determining, beyond a doubt, the relative advantage of different bucket shapes. The printed information on this subject heretofore has been extremely misleading, to say the least, and usually the result of incomplete theorizing within very narrow limits. The conclusions arrived at have usually been entirely different from those that would have been obtained had the theorist taken into account, instead of neglected, certain factors of extreme importance to the deductions.

We will not again parade that elusive ghost—"a new bucket shape"—that is conjured up by every suburbanite with a "mechanical turn of mind" who has wielded a garden hose. It is our intention, however, to present a few facts for your worthy consideration, and particularly to those of you interested in obtaining the best results from water wheel plants.

During the writer's experience in the design, construction and operation of tangential water wheels for the past twelve years, new types of tangential water wheel buckets have been brought out with startling rapidity; every rain seems to bring out a new crop—like mushrooms. Most of them do not last any longer than mushrooms. Some few, due to liberal advertising, are forced before the public, but usually die a natural death after a short time, as much because of poor engineering or financial disability, as weakness in bucket design. The average inventor fails to consider the work of those who have gone before, and suffers from the belief that if the patent office will grant a patent there must be superior results obtainable. Or, rather than giving actual results, such as Prony brake measurements on carefully designed wheels for comparison, he will state that it will "reverse a Pelton" when put on the same shaft, etc., all of which means nothing as far as relative efficiency goes.

Another frequent fallacy is that to get maximum efficiency it is only necessary to provide a bucket which will receive one blow at each revolution, usually at the instant of entering the stream.

To obtain the best efficiencies it is necessary to have the proper pipe line, gate valves, nozzles, water wheels and buckets, wheel case, wheel pit and tail-race, and all of these parts must be properly designed for the particular conditions under which they are to operate, and all will vary with the head or pressure—the water quantity and the revolutions which the wheel is to make. Many a water wheel bucket has been overworked for years, and then charged up with losses that occur because of its being improperly worn, due to this overwork. Again, buckets are frequently charged up with all kinds of losses which are really due to something for which the bucket



SOME OF THE TYPES OF BUCKETS USED IN THE EXPERIMENTS

A One of the early forms of Pelton. *B* Latest type of Ellipsoidal. *C* Hug. *D* One of the recent forms of Pelton.

materially altering the efficiency. Many hydraulic plants are in operation and developing not over 65 per cent. between the flume and water wheel shaft where the *bucket* itself is capable of developing 90 per cent., and where a very inexpensive change could be made which would increase the gross efficiency very materially and cause a great saving in the water bills. On the other hand, there are probably more errors made in buckets than in any other one element of a tangential water wheel plant. The writer knows of but one inventor, Mr. L. A. Pelton, who has based all of his work on tangential wheels on actual practical results obtained through laborious experimental work. All other shapes, as far as we know, are the result of a happy, or, usually, an unhappy thought, and it is curious to note how at variance are the is not responsible. Pressure, or wheel diameter, or speed on a given wheel, cannot be varied radically without

*A paper presented to the Seventh Annual Convention of the Pacific Coast Electric Transmission Association, June 16-17, 1903.

shapes and arguments put forth to support each type as it is introduced.

The Cazin bucket is built up on the entering lip and cut away on the sides, which are made rectangular, and Mr. Cazin issued quite a mathematical treatise, in the form of a trade catalogue, to prove the value of his type of bucket.

The ellipsoidal type of bucket is cut out in front like the Dodd, and is supposed to contain smooth interior cavity surfaces, whereas the De Reamer has a number of interior ridges or walls to guide the water in fixed lines along the surface of the bucket cavities. In the ellipsoidal, before mentioned, great stress is laid on the smooth interior surfaces, from which 1 or 2 per cent. is supposedly gained, and then the front is largely cut away, resulting in a loss usually much more than is gained by the smooth surface.

Some inventors insist that buckets should discharge from the top or edge nearest the wheel center, such as the Risdon and Hug. Others, again, that the discharge should be from the front and side furthest from the center, and still others, that this discharge should be from the sides, as in the Cazin, Berry Blue and Pelton. This latter class is by far the more numerous.

In actual practice, each bucket, of course, discharges to some extent on all three sides of the cavity, but the maximum discharge may be distorted to any particular point by changing the interior surface of the bucket cavity. Some inventors insist on few and others on many buckets located around the wheel periphery. In fact, the whole question of bucket design seems to be largely a matter of guess work, usually based on assumptions entirely at variance with facts, and therefore leading to wrong conclusions.

An inspection of the stream diagrams, made from actual experiments, will make this question of stream path over the surface of the different bucket shapes better understood. It should be born in mind that the bucket is doing work throughout its entire path, within the stream lines, and we therefore give the lines taken by the water in three different positions of the bucket. First, at the moment of entering; second, at the point of developing maximum power; and third, in its final position before leaving the stream. In these diagrams the same relative bucket and wheel and stream dimensions are maintained for each form, so that comparisons may be more readily made.

With these diagrams before us, let us bear in mind that to obtain the best possible bucket efficiency it is necessary that the water jet be taken up on the bucket surface and brought to as near rest as possible with the least loss of energy. This loss will then be made up of:

1. The discharge velocity with which the water leaves the bucket with respect to a point fixed in space. Note that this velocity will vary with every position of the discharge as bucket moves.
2. Air and surface friction inside the bucket.
3. Imprisoned water in the bucket.
4. Variation in the stream form, producing erratic conditions of impact and flow on the bucket surface.
5. That occasioned by the stream being displaced by the entering bucket.
6. Eddy currents in the buckets.
7. Water which does not give up all its energy to the bucket (a special case of the first condition mentioned above).

The following methods of correcting these losses suggest themselves:

1. If the water moves in a curved path on the bucket surface, being taken up on a surface as nearly tangent to the entering jet as possible, and is turned through a curve of as nearly 180 degrees as possible, still allowing the discharge to clear the back of the next bucket, and the discharge is at the same distance from the wheel center at all times, the first loss will be kept down to a minimum.
2. If the water moves in a smooth curved path at all times, as shown in the Pelton bucket diagram (Photo A)

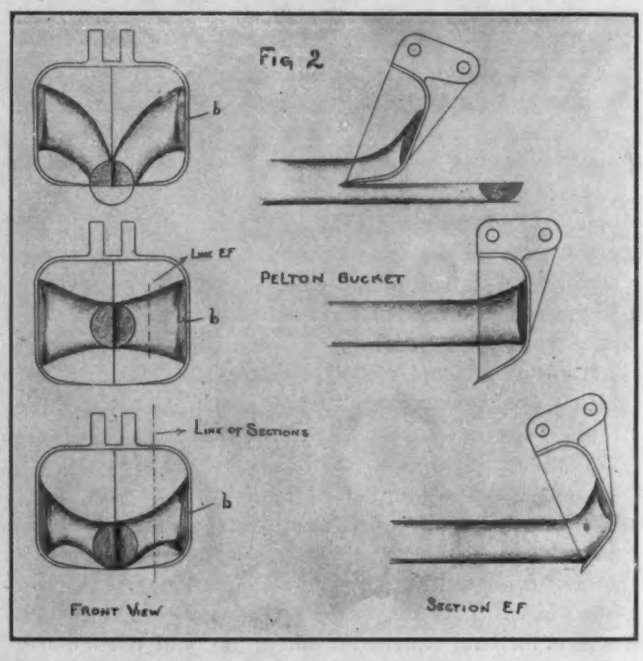


PHOTO A. DIAGRAM OF DISCHARGE FROM PELTON BUCKET, NOTE THIN FAN LIKE DISCHARGE AT B

and the stream form is retained, spreading out gradually and encountering no sharp corners or angles, and the discharge is thin and fan-like on the sides, and the least number of buckets used, then the air and surface friction will be a minimum.

3. The imprisoned water will cause very little loss if the bucket surfaces are smooth and so shaped on the back and front that the water, after expending its energy, will freely leave the wheel.
4. Variations in stream form producing erratic conditions of impact and flow will be avoided by carefully following the angle of the front and the curvature of the cavity surfaces.
5. The shape of the cutting edge and the dividing knife, and their relative angles to the stream, are the principal causes of the loss occasioned by the displaced stream.

There are still other losses which should form an important consideration in wheel design, but which are not directly affected by the bucket shapes. These are:

8. Journal friction.

9. Windage due to the wheel acting as a centrifugal blower.

10. The losses in the nozzles, gate valves and pipe lines.

Every water wheel plant has all of these losses to a greater or less extent, and it is obvious that when 80 per cent. is then obtained from an operating wheel, the improvement of any one of these, or, for that matter, the entire elimination of any single loss, if this were possible, would not, to any great extent, improve any wheel's gross efficiency. The writer has a number of times obtained as high as 90 per cent. efficiency in laboratory test on buckets only.

Let us give some attention to the above detailed losses, and endeavor, as far as possible, to determine those points, the careful calculation of which will obtain for us the best possible tangential water wheel bucket.

1. Given a certain stream of water at a given spouting velocity, it is advisable that this be taken upon the bucket surfaces of just enough buckets to catch every particle of water on the dividing wedges and turn it all on the curved surfaces, and discharge it at just enough velocity (and entirely in a direction at right angles to the entering stream axis) to clear the next following bucket. This resulting velocity will be the tangent of the discharge angle, multiplied by bucket velocity.

2. The air and surface friction must be maintained as small as possible by the use of a nozzle which will give a perfectly circular and solid stream. The bucket surface and cutting edges must be of a shape which, with a minimum wetted surface, will allow the stream, without crowding at any point, to spread out in a thin fan-like discharge on each side. The surface must be such that the water will not adhere, and as smooth as possible.

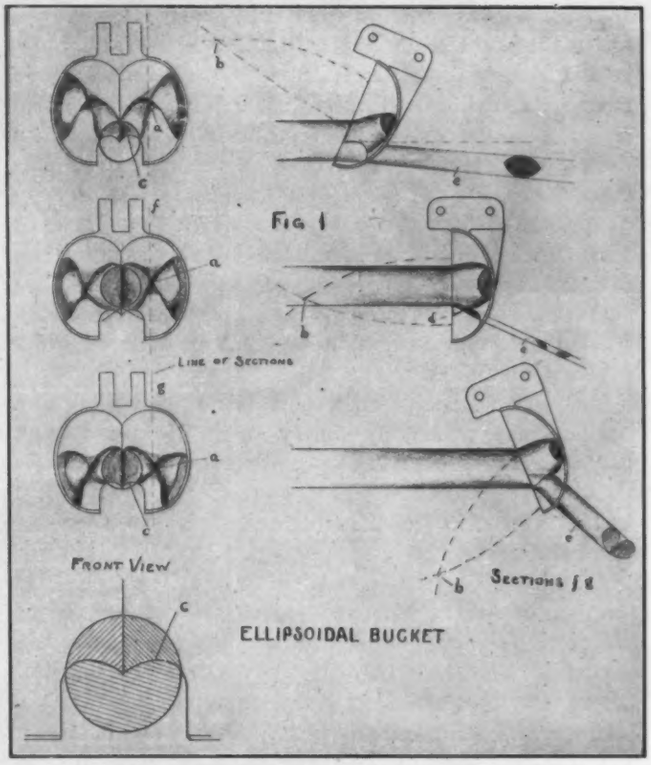


PHOTO C. DIAGRAM SHOWING PATH OF WATER IN AN ELLIPSOIDAL BUCKET IN ITS DIFFERENT POSITIONS. NOTE POINT OF DISTURBANCE AT A, FLAT IMPACT AND DIVISION IN TWO PLANES AT C, NODES OF DISCHARGE B, LEAKAGE OF PRESSURE WATER E

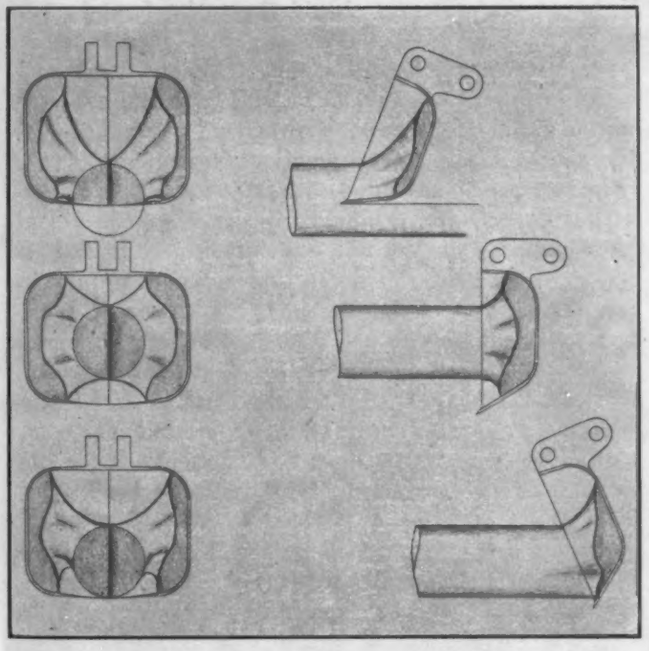


PHOTO B. DIAGRAM SHOWING THE EFFECT OF OVERCROWDING A WATER WHEEL BUCKET RESULTING IN UNEVEN MECHANICAL EROSION CUTTING OUT THE CORNERS RAPIDLY

The surface may be ground and polished, or better, ground and well painted with a special compound. If all of these points are carefully studied out and the front of the bucket properly shaped and not cut away too low, the imprisoned water will not cause any appreciable loss.

The windage will also be a minimum if the number and surface of the buckets is a minimum.

The above losses and considerations for their prevention are all of such a nature, and so entirely interdependent, that their quantitative value cannot be predetermined except in a general way. In designing a water wheel, however, it is certain that the exercise of the most careful judgment is necessary in the laying out of the surfaces, so that all the losses, or at least their sum, or total bucket loss, will be kept down. Thus, if too much bucket surface be allowed, we increase both surface friction and windage for a given output, and if we attempt to cut these down by reducing the surface, we crowd the stream, so that eddy currents will occur and the stream will not properly discharge from the bucket side, as shown in Photo B.

It will now be seen that it is absolutely impossible to get equally as good results from a certain shape of bucket, under all conditions of wheel and stream diameter and water pressure, but that to get the best efficiency, a bucket must be designed for each set of conditions.

When an investigator says, "Suppose no frictional resistances exist in the bucket, and let the stream be prevented from spreading laterally—also neglect losses due to impacts, loss of head in the nozzle, journal friction and resistance of the air"—however interesting a conclusion he may come to mathematically, the result to the purchaser or the builder is not only entirely useless, but frequently misleading to a dangerous degree.

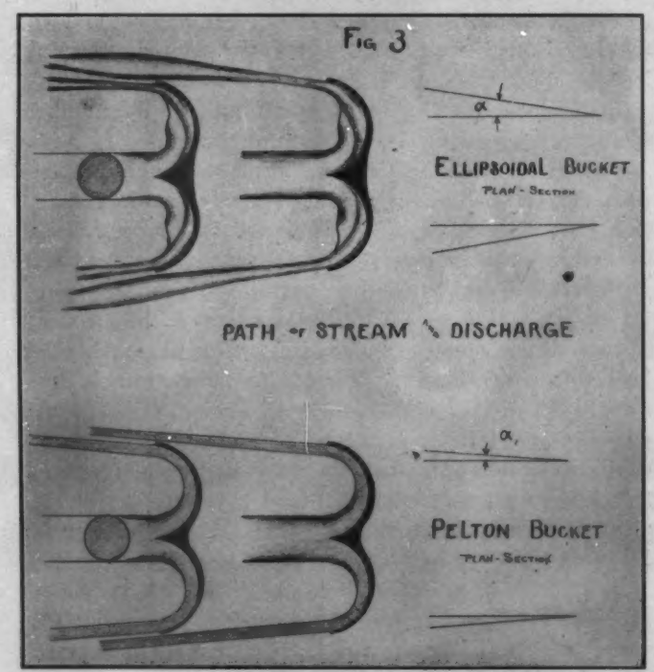
By carelessly omitting some of the above considerations, many makers who have obtained very good results on some one wheel, fail to secure even a reasonable efficiency from others, built on similar lines, but for working under different conditions.

The writer believes that there is no such thing as a bucket shape, which, by simply enlarging or reducing, may be adapted to any set of conditions.

Some of the familiar bucket types are grossly deficient in the most elementary requirements for efficiency and best practical results.

All bucket shapes may be divided into two classes, in the first of which we have a variation in the shape of the cups on each side of the dividing wedge, and the second in which we vary the front wall or entering lip. Let us give some attention to these two points.

In the first place, no stream of water can divide on the central wedge and gradually spread out, if the surface of the bucket is concave with a deepest point (See Photo C), as there will be a tendency for all the lines of flow to cross on this point *a*, and then spread out again after passing over it. This crossing or "impact accumulation" and the consequent eddy currents at the deepest point cause more rapid wear here than elsewhere, as also a considerable reduction in efficiency. The water again spreads out, after crossing the deepest point, but before leaving the side of the bucket the curvature of the walls tends to



PLAN VIEW OF BUCKETS SHOWING THE THIN DISCHARGE OCCURRING FROM THE PELTON AND SMOOTH FLOW IN THE CAVITIES.

PHOTO D. PELTON BUCKET SHOWING ABSENCE OF WEAR ON THE BACK AND FRONT WALL ALTHOUGH BUCKET IS WORN THROUGH DUE TO LONG CONTINUED USE WITH TOO LARGE A STREAM

produce a second node, as shown at *b*. It is the writer's belief that there should be no single deepest point in a water wheel bucket, but rather that the flowing stream, after impact on the dividing wedge, should follow, practically, a cylindrical surface, so that the stream may spread out in a fan like shape at discharge, as shown in Photo A.

In reference to the front of the bucket, this should be neither too high nor too low. If the front be too high, as in the Cazin, then it must be set at such an angle of entry to avoid disturbing the stream, that there will be eddy currents set up; if too low, all the water will not be caught without a great increase in bucket surface. Under no circumstances should the entire front be left out, as in the Berry and Doble as used at Blue Lakes.

Some wheel builders state that if the bucket has any front in line with the stream, this "slaps" or "pushes" a portion of the stream out of the way and accordingly reduces the efficiency by this amount of lost stream. This is not the case by any means, as far as the design of Pelton bucket is concerned, but on the contrary, the stream enters perfectly and entirely without disturbance. In a bucket with a front wall and properly designed throughout, the solidity of the stream is not interferred with, even to the slightest extent, until impact commences on the central interior dividing knife. All buckets which show wear and have been properly set and operated confirm this, as no wear occurs on the exterior of the front wall. The bucket here illustrated, although worn out on the inside, is clean on the front wall and back. See Photo D.

Another fallacy shared in by many engineers is the misstatement that a bucket without a front wall cuts the stream in but one place. Nothing could be further from the truth. Every bucket with a dividing wedge, splits the stream in two places. One of these being the plane of rotation through the central wedge, and the other

containing the boundary line of the bucket and parallel with the stream axis. The stream is thus divided into three parts at the intersection of the two planes, as shown in Photo Cc and Photo E, illustrating the ellipsoidal bucket.

Any bucket having a central dividing wedge divides the stream into two planes, whether the bucket has a front wall or not. There are no exceptions to this rule, and by the very nature of things it is impossible for a bucket to enter the stream without cutting the stream with the front or bottom surface parallel with the shaft. This double plane division occurs in the buckets of the Pelton, Risdon, Dodd, Hug, DeReymer, Ellipsoidal and Berry, and the more nearly the stream (in both divisions) is taken up in the line of flow, the better the efficiency that will be obtained.

into three parts by two planes. The accompanying Photo E is of an ellipsoidal bucket in which the patentee claims this does not occur and where the three sections by two planes are clearly shown. (See, also, Photo EE.)

We do not see how anything would be gained in the way of efficiency, if the division into three parts could be avoided, as has been erroneously claimed by the inventor of the ellipsoidal bucket. The entry of the bucket front line into the stream, if properly made, can be the cause of but an infinitesimal amount of power loss, if any, which we are by no means prepared to admit. In fact, a bucket, to give anywhere near a proper efficiency, in addition to the reason given above, must have a considerable front wall, otherwise, after impact has occurred on the bucket surface, the jet will spread, and a large percentage of it find its way out, without having given up

PHOTO E. ELLIPSOIDAL BUCKET SHOWING THE STREAM DIVISION IN TWO PLANES AND THE "NODES" IN THE DISCHARGE WATER LIKE A STRING IN VIBRATION INSTEAD OF A THIN FAN LIKE DISCHARGE. COMPARE PHOTOS C, G, H, T

With buckets of the Berry and Ellipsoidal types, a large percentage of the water entering each bucket strikes a comparatively flat portion of the bucket. See Photo Cc. If we bear in mind that the efficiency of a flat surface running under the same conditions is theoretically only fifty per cent., and practically much less, than when received on the wedge we readily see that this loss, due to part of the stream striking on a flat surface drags down the efficiency that would be obtained if the bucket were provided with a curved front surface or entering lip.

In regard to the division of the water jet in two planes: Consider for a moment any bucket in a position where the stream is partly entering it and the remaining portion of the stream passing on to the bucket next ahead; then that portion which enters the first bucket, has been divided by one plane, namely—that passing through the bucket front line—and again in the bucket division has again occurred on the central wedge or it is clearly split more than a small part of its velocity, and therefore its energy. This is not only so during entry, but during the entire passage of the water through the stream, and, as paradoxical as it may seem, it is a fact, that a greater disturbance in the stream, as far as those conditions which should be maintained for maximum efficiency are concerned, is caused by cutting down the height of the front wall below the splitting wedge than by leaving it well up. This is not a theory nor mathematical deduction, but a readily demonstrable fact which any interested parties may very easily prove.

There is another branch of this subject which is of considerable interest, and one, if carefully studied, that leads us to very important conclusions, viz., the erosion or bucket wear which occurs in every plant to a greater or less extent. As stated before, the course followed by a stream of water, after impact on a Pelton bucket, is such as to give a discharge almost entirely from the side of the

PHOTO EE. ELLIPSOIDAL BUCKET SHOWING THE TWIST IN THE DISCHARGE AND THE LEAKAGE OF PRESSURE WATER THROUGH THE FRONT EVEN THOUGH STREAM HAS FIRST FULLY ENTERED THE BUCKET CAVITIES

bucket. This is shown diagramatically in Photo A, and also experimentally in Photos F and G.

In this latter photo we have a stationary Pelton bucket receiving the correct size stream and discharging it from the sides. The course taken by the discharge will be slightly different as the wheel rotates, but the discharge will always be parallel with the entering jet, as illustrated in Photo H. If these statements are correct, we would find in properly designed and installed Pelton plants, where all the adjustments and sizes of streams used were correct, that the buckets would wear evenly, at least for a considerable time, until the slight pits, which almost invariably occur, would start local action, resulting in considerable wear spreading around these pits.

It is a fact worthy of notice, although I think not mentioned in the discussion on "erosion" at last year's proceedings, that erosion met with in hydraulic practice is usually of two kinds. First, we have that due to the impact of cutting particles, which acts exactly as a sand blast—the sharp corners of the quartz sand particles cutting away the material of the bucket surface. A bucket eroded by this process is shown in Photo P. Secondly, we have a chemical erosion or corrosion, occasioned, I believe, by the escape of imprisoned air or air or other gas in solution, which released suddenly under high pressure may carry with it a certain amount of nascent oxygen, which on the clean metal surface would promote rapid oxidation. It usually starts at any imperceptible inequality in the castings, such as infinitesimal blow holes. The water moving over the surface and jumping across the blow hole crater releases the oxygen of the air, possibly more readily than the nitrogen. This gives us a small pocket, or blow hole, having clean surfaces from the water friction, filled largely with oxygen gas. The oxygen combines with the clean metal, forming an oxide coating, which is cleaned off by the water friction, which will invariably occur at the slightest change in position of bucket. The result is that the oxidizing process is repeated—the hole rapidly growing larger.

We would expect, if the above theory of chemical erosion is correct, to find the oxidized pits, as they be-

PHOTO F. TANGENTIAL WATER WHEEL FITTED WITH PELTON BUCKETS SHOWING THE DISCHARGE AT ALMOST ZERO VELOCITY (THE INDIVIDUAL SLOW MOVING DROPS OF DISCHARGING WATER ARE OBSERVABLE) AND THAT THE SHAPE OF THE JET IS MAINTAINED UNTIL IMPACT IN THE CENTER OF THE BUCKET WHERE THE ENTIRE ENERGY IS REMOVED FROM THE WATER BY THE BUCKET RESULTING IN MAXIMUM EFFICIENCY

PHOTO G. PELTON BUCKET SHOWING PARALLEL DISCHARGE FROM BUCKET SIDES

come larger, increasing more rapidly in the direction of the bucket wedge, or creeping towards the direction from which the stream approaches, rather than from it, as the oxygen would naturally be released on the side of the pit from which the stream approaches. Such seems to be actually the fact where we can obtain an example of chemical erosion independent of mechanical erosion.

Photo J shows you a bucket taken from one of the wheels at the Santa Ana Station of The Edison Electric Company after about twenty-seven months operation, during which it was driving a 750-kilowatt generator from a single stream under about 700 feet head. Here you will find the oxidized pits above mentioned, which are of the color of gun metal—the oxidized depressed surfaces being clearly outlined from the smooth steel surface over which the water flows. If the erosion of these pits were due to eddy currents, the oxidized surface would be removed by such erosion. Moreover, if mechanical erosion accounted for the pitted surface of most of our water wheels, we would find the dividing knife, or splitter, the most heavily worn part. This, however, is not the case in most instances, the pitting usually occurring in the bottom and sides of the cavities. It will be readily seen that, after these pits grow large enough to alter the course of the water, they will completely change the path of the jet in the bucket cavities, and we will then have all sorts and kinds of erratic shapes, which shapes are in no way governed by the original curves of the buckets. We thus find on the same wheel buckets worn through in entirely different spots, bearing absolutely no similarity to each other, although they all started out under exactly equal conditions.

The small bronze Doble bucket with the open front, originally used in the Blue Lakes plant, Photo K, clearly shows the beginning of this pitting process and also the direction of the water flow over the bucket surface. This direction of flow also shows the impact, on a comparatively flat surface, in open front buckets of this type, as mentioned before, unless built with a front wall.

In water jets carrying imprisoned air, or air or gas in solution, due to the high pressure, we would expect to

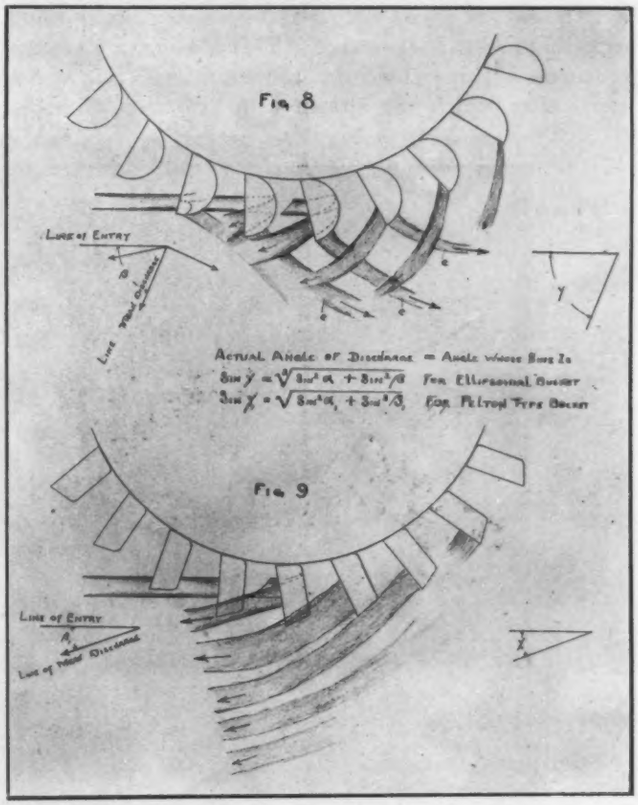


Fig. 8
Line of Entry
Line of Jet Discharge
Actual Angle of Discharge = Angle whose Sine is
Sin γ = √(Sin²α + Sin²β) For Ellipsoidal Bucket
Sin χ = √(Sin²α + Sin²β) For Pelton Type Bucket
Fig. 9
Line of Entry
Line of Jet Discharge

PHOTO H. DIAGRAM SHOWING THE PATH OF DISCHARGE FROM THE ELLIPSOIDAL BUCKET (FIGURE 8) AND FROM THE PELTON BUCKET (FIGURE 9)

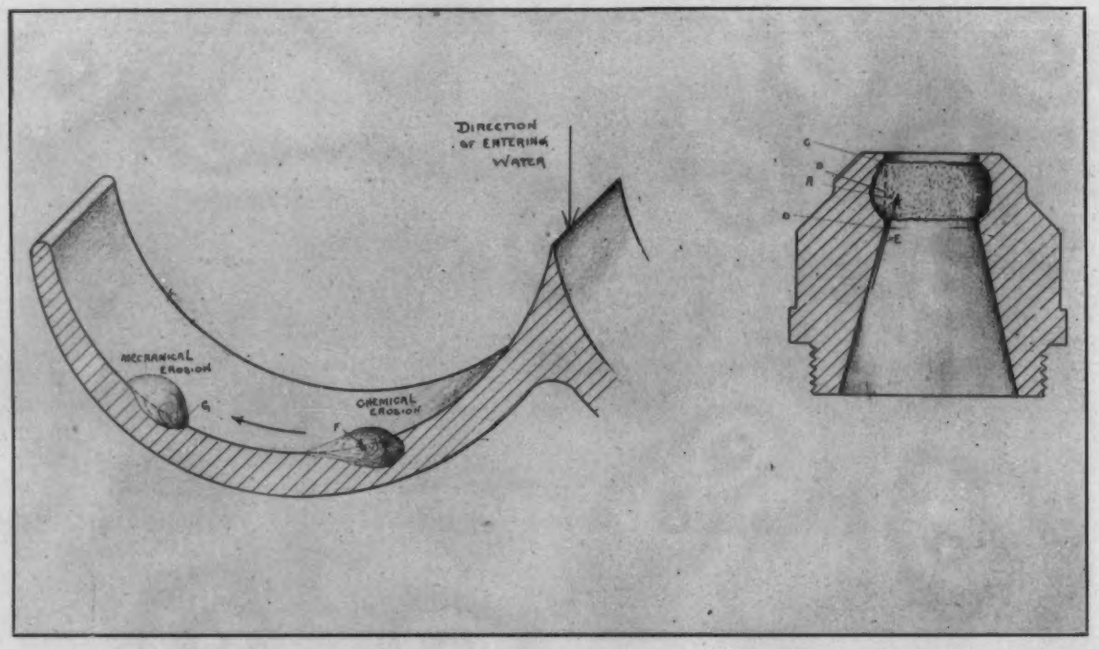


PHOTO I. DIAGRAM OF CHEMICAL AND MECHANICAL EROSION ORIGINATING AT POINTS F AND G RESPECTIVELY AND IN THE NOZZLE TIP WHICH IS A SCALE DRAWING FROM A TIP ERODED IN ACTUAL OPERATION---CHEMICAL EROSION ORIGINATING AT A

find, on relieving this pressure, a gas discharge from the outside of the stream. Photo L shows you a stream under fifty-foot head, carrying air in solution. The stream at the instant of leaving the tip is perfectly clear; an instant later, or about two diameters from point of issue, we find a slight enlargement of the stream, which the writer believes to be due to the imprisoned gas freeing itself on the relief of pressure. This disengaging process continues in this instance for about fifteen stream diameters, after which the stream begins to again clear up, although at no point is its rigidity or shape interfered with.

Photo M shows you another example, and under such radically different conditions as to lead me to the belief that this condition exists throughout the entire field of hydraulic practice. You see here a jet from a Pelton needle nozzle under a pressure in excess of 1900 feet head at the plant of The Edison Electric Company in southern California. The jet is of a size suitable for developing an overload on a 750-kilowatt generator, and the fog or

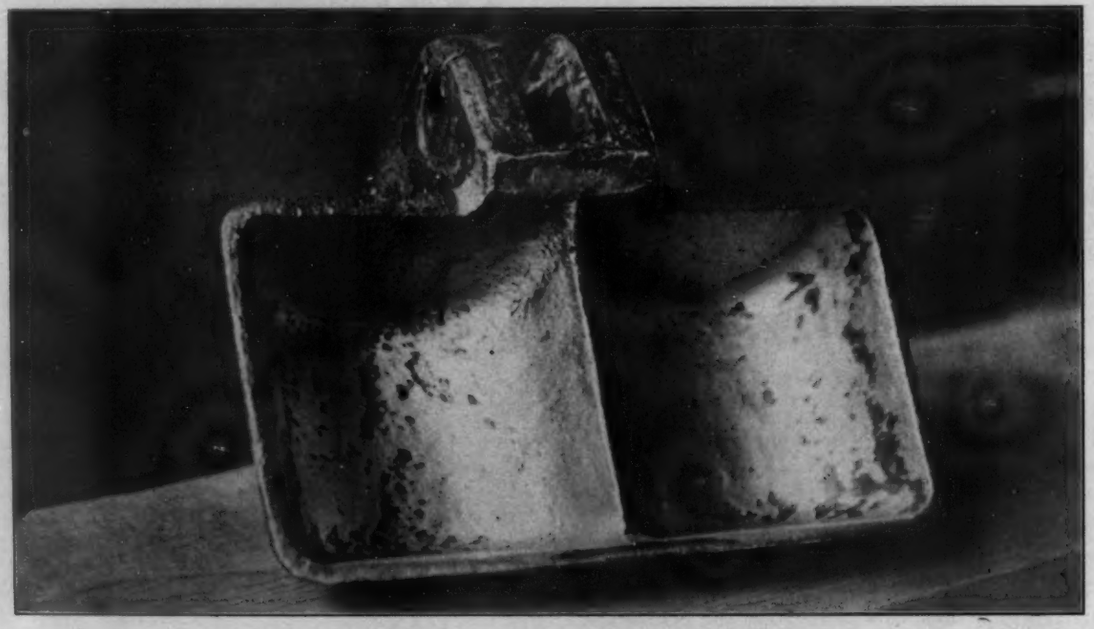


PHOTO J. CAST STEEL PELTON BUCKET FROM THE EDISON ELECTRIC COMPANY'S SANTA ANA STATION SHOWING THE EVEN WEAR WHEN THE PROPER SIZE STREAM IS USED, SHOWING ALSO THE CHEMICAL EROSION AND OXIDIZED PITS IN THE STEEL SURFACE. THE ORIGINAL PAINT IS STILL OBSERVABLE ON THE BACKS AND EDGES OF THE BUCKET AFTER SEVERAL YEARS USE

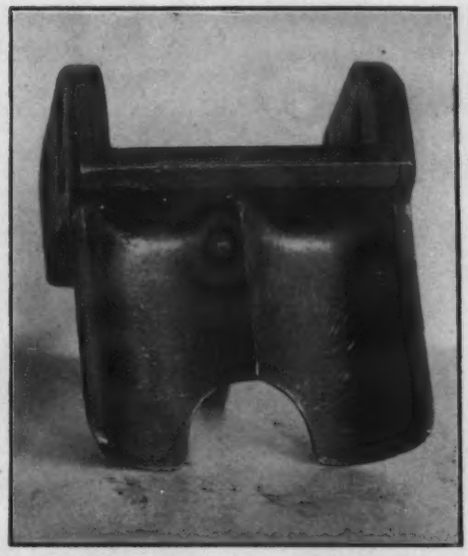


PHOTO K. A BUCKET FROM ONE OF THE EARLY BLUE LAKES WHEELS SHOWING THE IMPACT ON THE FLAT SURFACE AND THE CHEMICAL EROSION ON THE INSIDE

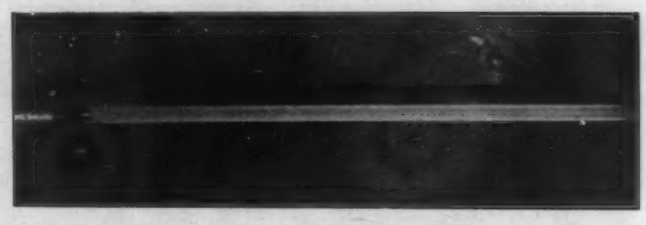


PHOTO L. A WATER JET FROM A STANDARD PELTON TIP

PHOTO M. A STREAM OF WATER FROM A PELTON NEEDLE NOZZLE UNDER 1923 FEET HEAD AT THE STATION OF THE EDISON ELECTRIC COMPANY, LOS ANGELES DEVELOPING 86.2 PER CENT. EFFICIENCY

"water dust" immediately surrounding the jet shows clearly the disengagment of imprisoned gas. This is best observable at from one to ten diameters from the tip, and is undoubtedly a condition that exists on the bucket surface, as well as immediately surrounding the jet at point of issuance.

Photos N and O illustrate a needle nozzle under comparatively low pressure, and the water dust is here also observable at from five to twenty stream diameters distant from the tip. In each of these cases the stream is in particularly good focus, and the water dust was more clearly observable in the investigations than it is shown

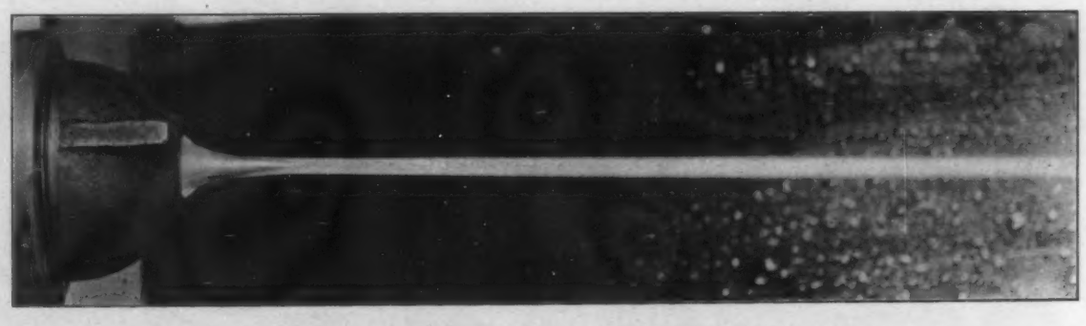


PHOTO N. A STREAM OF WATER FROM A PELTON NEEDLE NOZZLE

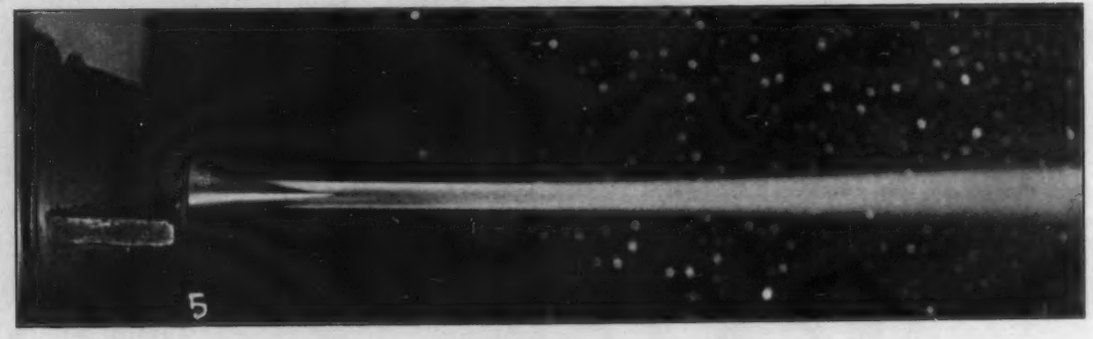


PHOTO O. A STREAM OF WATER FROM A PELTON NEEDLE NOZZLE

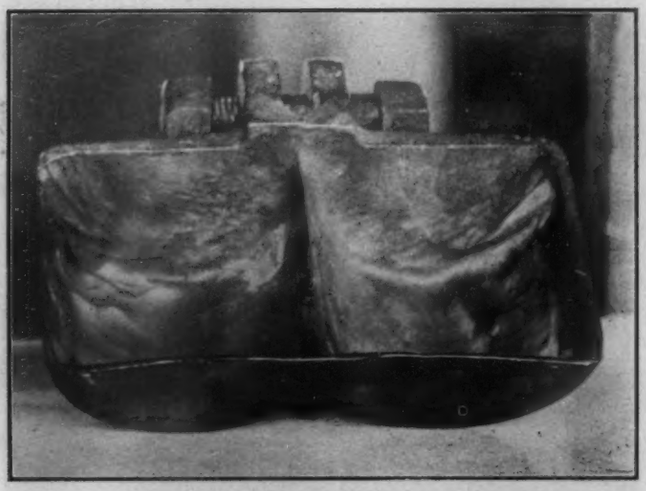


PHOTO P. EARLY TYPE OF PELTON BUCKET ON WHICH HAS BEEN USED TOO LARGE A STREAM OF VERY GRITTY WATER, A COMBINATION OF MECHANICAL AND CHEMICAL EROSION AND EXCESSIVE WEAR IN THE CORNERS DUE TO THE OVERCROWDING WITH THE LARGE STREAM AS SHOWN IN PHOTO D, NOTE THE ENTIRE ABSENCE OF WEAR ON THE FRONT WALL SHOWING IT DOES NOT INTERFERE WITH THE WATER JET

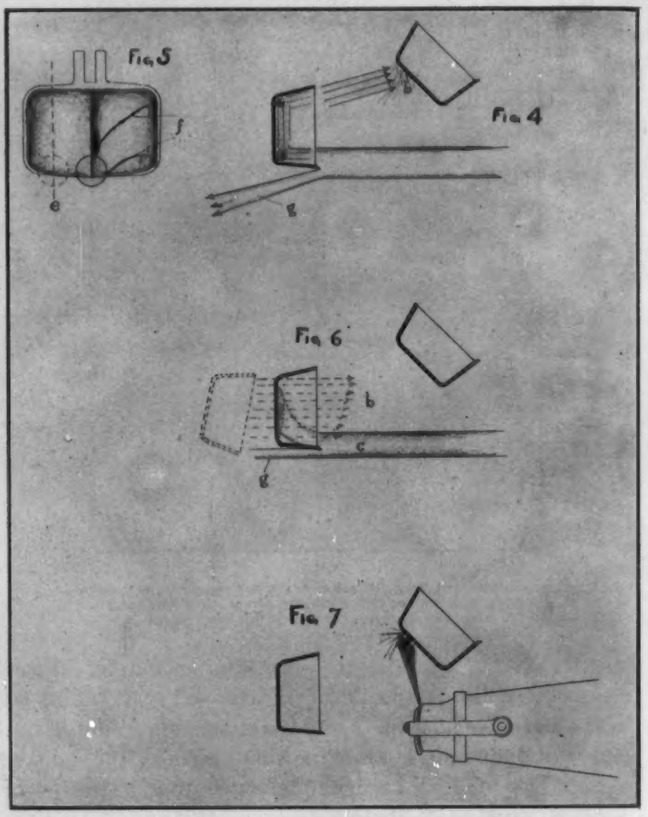


PHOTO Q. FIGURE 5-6, THE PATH OF WATER JET THROUGH THE PELTON BUCKET FIGURE 4 A DIAGRAM SOMETIMES USED BUT INCORRECT TO EXPLAIN THE WEAR THAT OCCASIONALLY OCCURS ON THE BACKS OF WATER WHEEL BUCKETS, FIGURE 7 THE CORRECT EXPLANATION OF WEAR ON THE BACKS OF WELL DESIGNED BUCKETS

in the photograph. It is perfectly obvious, if this theory is correct, that much of the wear that occurs in the interior of nozzle tips would also be explainable. For it is certain that where changes of cross section occur, there is a corresponding change in stream velocity, and, when this is not in accordance with the laws of least resistance, the oxygen or other gas would be released in exactly the same way—causing the pitting surfaces inside of the nozzle tip.

I believe this to be the correct explanation of chemical corrosion, and think that in most cases in practice we have a combination of chemical and mechanical erosion.

Paint acts exactly as a sheet of paper or rubber cushion protecting a piece of glass under a sand blast—the paper or rubber not in any way being damaged by the impact of the particles of sand, but where cut away so that the glass is exposed to the cutting grains, the hard surface of the glass or of tool steel will be very

PHOTO R. INSTANTANEOUS PHOTOGRAPH OF TANGENTIAL WHEEL FITTED WITH PELTON BUCKETS WHEN RUNNING AT HIGH EFFICIENCY AND SHOWING THE DISCHARGE FROM THE SIDES OF THE BUCKETS PARALLEL WITH THE ENTERING JET THIS PHOTOGRAPH ALSO SHOWS CLEARLY THAT THE FRONT OF THE PELTON BUCKET ENTERS THE STREAM WITHOUT SHOCK OR DISTURBANCE OF ANY KIND AND THAT ALL OF THE ENERGY IS REMOVED FROM THE WATER BY THIS SHAPE OF BUCKET

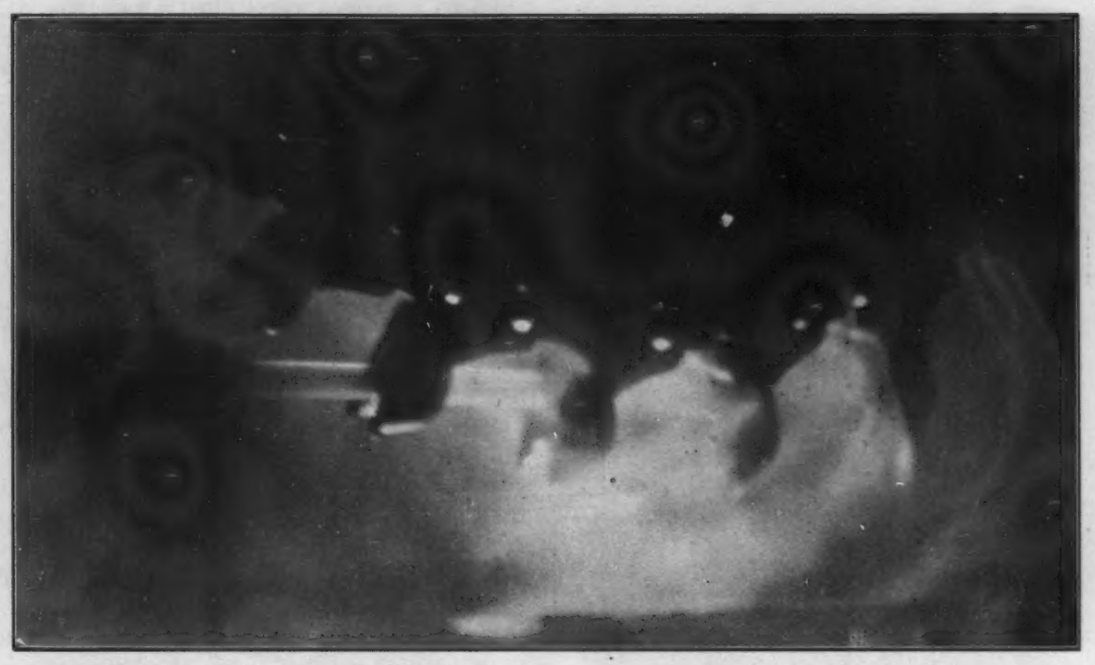


PHOTO S. INSTANTANEOUS PHOTOGRAPH OF TANGENTIAL WHEEL FITTED WITH DODD BUCKETS AND RUNNING AT MAXIMUM EFFICIENCY SHOWING THE DISCHARGE FROM THE BUCKETS TO BE BELOW THE POINT OF ENTRY AND ALL OF THE STREAM FULLY CAUGHT IN THE BUCKETS AND REVERSED IN DIRECTION RESULTING IN HIGH EFFICIENCY

rapidly cut. By holding your finger under the sand blast, the finger nail is rapidly cut away, although the sand makes no impression on the softer skin surrounding it. The observation of this fact led the Pelton company years ago to adopt a special rule in regard to painting its buckets—the paint proving the best possible protection. In fact in regular operating plants, if the buckets are of good design and are kept thoroughly painted, they will last an indefinite length of time.

Photo P shows you the interior of a bucket, the back part of which is shown in Photo D. This bucket was over-crowded, as shown from the cutting in the corners. In spite of this the outside of the front wall is not worn in any way, due to the stream cutting the wheel. The slight wear on the dividing lip is not as great as on the dividing wedge inside the bucket. Considerable notoriety has been given by a competitor to a large Pelton bucket originally in use at the

PHOTO T. INSTANTANEOUS PHOTOGRAPH OF TANGENTIAL WHEEL FITTED WITH ELLIPSOIDAL BUCKETS AND RUNNING AT MAXIMUM EFFICIENCY SHOWING THE LOSSES THAT OCCUR DUE TO THE STREAM PARTLY DISCHARGING THROUGH THE FRONT OPENING BEFORE ENERGY HAS BEEN TAKEN OUT AND DISCHARGING FROM THE FRONT CORNERS OF THE BUCKET RESULTING IN AN UNNECESSARILY LARGE DISCHARGE ANGLE, REDUCING THE EFFICIENCY OF THE WHEEL

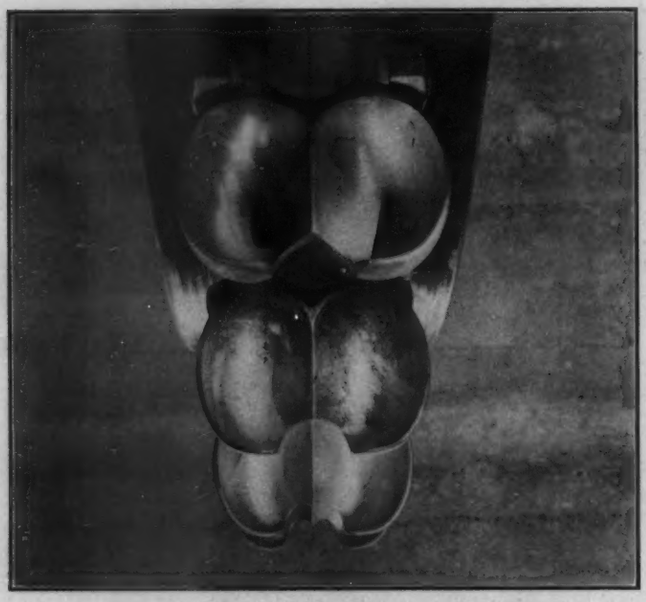


PHOTO U. ELLIPSOIDAL BUCKET AT EDISON MILL CREEK NO. 3 STATION SHOWING BY THE WEARING OFF OF PAINT AFTER SEVEN HOURS RUN THAT DISCHARGE OCCURS FROM THE FRONT OF THE BUCKET AND NOT FROM THE SIDES AS IT SHOULD FOR BEST EFFICIENCY

Nevada Power Company's plant on account of the unusual amount of wear on the back. This has been explained by parties unacquainted with the facts as having occurred as shown in Photo Q, Figure 4. The water does not, however, take this course through a Pelton bucket, as we have already shown you, Photo A, but takes the course as shown in Figure 5 and Figure 6 of Photo Q.

Figure 7 shows the way that the bucket in question received its wear. I have made several inquiries, endeavoring to get hold of this worn bucket to exhibit before you, but was not able to obtain it. It is no defect in the bucket curves if the back portion of the bucket is worn, due to water impact from some entirely different source than the bucket curves.

Photo F and Photo R shows you a Pelton wheel in operation at the point of best efficiency, and shows that the water impact and discharge all occurs vertically under the wheel center and within a very short arc of stream contact; that there is no disturbance occurring in the stream itself due to the front wall of the Pelton bucket entering the stream. We will also show you this experimentally on an actually operating wheel in a few moments.

Photo S shows you a Dodd wheel in operation when running at its best efficiency, and showing the discharge of the water through the front of the bucket at a point further removed from the wheel center than the entering water as claimed in Mr. Dodd's patent.

This slide also clearly shows the water entering one bucket but not yet leaving it, the bucket having to advance several stream diameters before it begins to discharge. The second and third buckets are also shown still receiving the stream, and the fourth bucket is shown with the water leaving it, although no water is entering.

Photo T shows a wheel fitted with ellipsoidal buckets operating at point of best efficiency. One bucket has just started to enter the stream; the second bucket is in full action, the third bucket is just receiving the last particle of water, and the fourth bucket is just discharging the last particle of water. All of the buckets show clearly the loss of water through the open front wall, as pointed out above. This water still contains considerable energy, resulting in a large falling off in efficiency. The efficiency of this type of bucket will decrease as the head decreases, the result being that for large streams under low heads such a large quantity of water is lost through the front opening as to very considerably reduce the efficiency below that obtainable with buckets having a front wall.

Photo V shows one of the Pelton buckets at the Edison Mill Creek Station No. 3, which was painted with a single coat of asphaltum varnish, allowed to dry three hours and then put under operation, driving a 750-kilowatt generator at about full load for a period of twenty hours, after which it was shut down and this photo taken. The photo clearly shows from the surfaces where the greatest amount of varnish is worn away that the discharge occurred from the sides of the bucket and not from the top and front as has been sometimes claimed.

Photo U shows an ellipsoidal bucket at the Edison Mill Creek Station No. 3 painted in the same way with a coat of asphaltum varnish and operated for a period of seven hours, driving a 750-kilowatt generator at about full load. In this case the greatest quantity of wear has occurred from the front portions of the bucket, exactly as we would expect it from a study of the foregoing photos, the discharge occurring in exactly the same way as in the Dodd bucket, Photo S, with the exception that the Dodd bucket

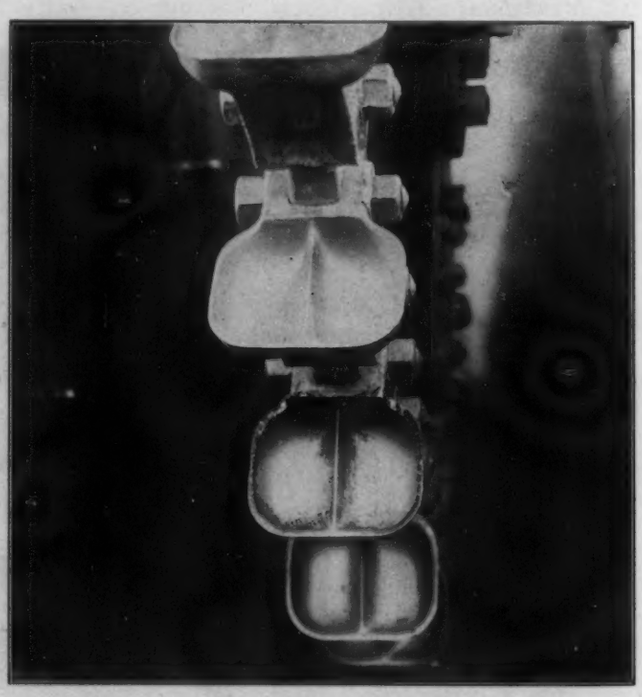


PHOTO V. PELTON BUCKET AT EDISON MILL CREEK STATION NO. 3 SHOWING BY THE WEARING OFF OF PAINT AFTER TWENTY HOURS RUN UNDER 1923 FEET HEAD THAT THE DISCHARGE OCCURS FROM THE SIDES AS IT SHOULD FOR BEST EFFICIENCY

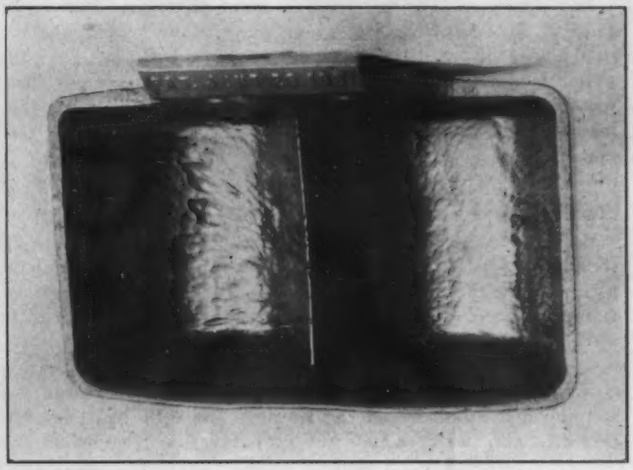


PHOTO W. WORN BUCKET SHOWING CHEMICAL EROSION CREEPING TOWARD THE CENTER DIVIDING WEDGE

has caught all the stream none of it discharging through the front wall.

The inevitable conclusions are that the greatest care and best judgment must be exercised in designing a bucket for each case. Certain it is, the bucket should have a front wall, joining cylindrical surfaces, which meet in a central apex or wedge, as distinguished from open front types and those having cups with deepest points in them, for the water to form eddy currents. It is a strange thing that mining companies will pay high prices for each inch of water and then use it over cheap wheels, cheap only in first cost, but probably costing hundreds if not thousands of dollars each year in their extravagant use of water. Some power companies are doing the same thing, except on a more magnificent scale. This condition of things is similar to that case, all too frequently met with, of cheap steam engines and boilers, whose extravagent use in coal constantly keeps the owner's nose hard up against the grindstone. There is, however, this difference, a good water wheel, properly set and cared for, will always be efficient, if kept in good condition, whereas a good steam engine, if not in skilled hands, is more apt to deteriorate. A little conservative figuring will frequently demonstrate, beyond a doubt, that a property struggling along under a burden of indebtedness would be easily placed on a proper paying basis by the use of more efficient water wheels.

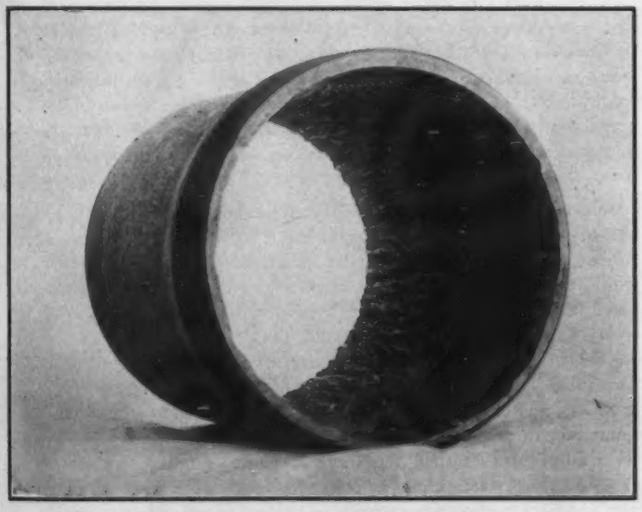
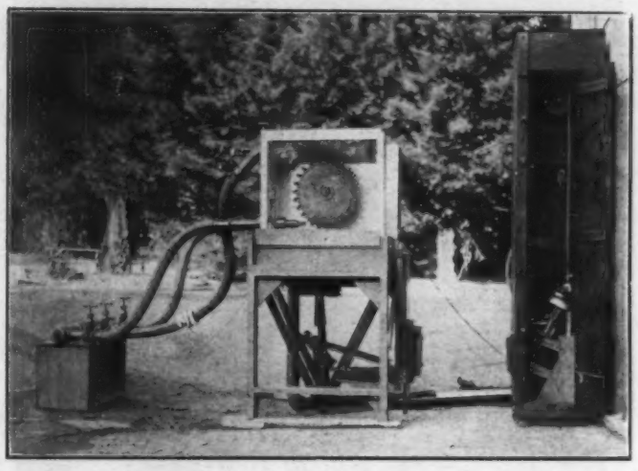


PHOTO X NOZZLE TIP SHOWING CHEMICAL EROSION IN JAR OR OUTLET END AND MECHANICAL EROSION ON NEAR OR INLET END

THE CHAIRMAN. Gentlemen of the convention, you have heard the very interesting paper by Mr. Henry on water wheels, and the effect of the jet on various shaped buckets, etc. Is there any discussion, or are there any questions that any one would like to ask?

MR. VAN NORDEN. Mr. Chairman, one point was brought up that there was not a great deal of stress laid on, and which is really, I think, a matter of very great importance. In his pictures Mr. Henry showed the cause of erosion on the back of the buckets, due to leakage through a leaky or faulty hood on the nozzle. I think, perhaps, that looks as if it might be a condition that, although it might happen at some times, would not always be the case. But, as a matter of fact, the same erosion has actually occurred in our plant. Although we have not got a cut-off nozzle, we have the hood over it, which practically answers the same purpose, and we have some slight erosion due to that very cause. In fact, when the hood is up and the wheel is standing still, the wheel will begin to revolve backwards, showing that there is more or less water diverted upward from the hood when it is up. There are times when the hood is partly on, which would cause the same thing, so I think Mr. Henry's stand is very well taken.



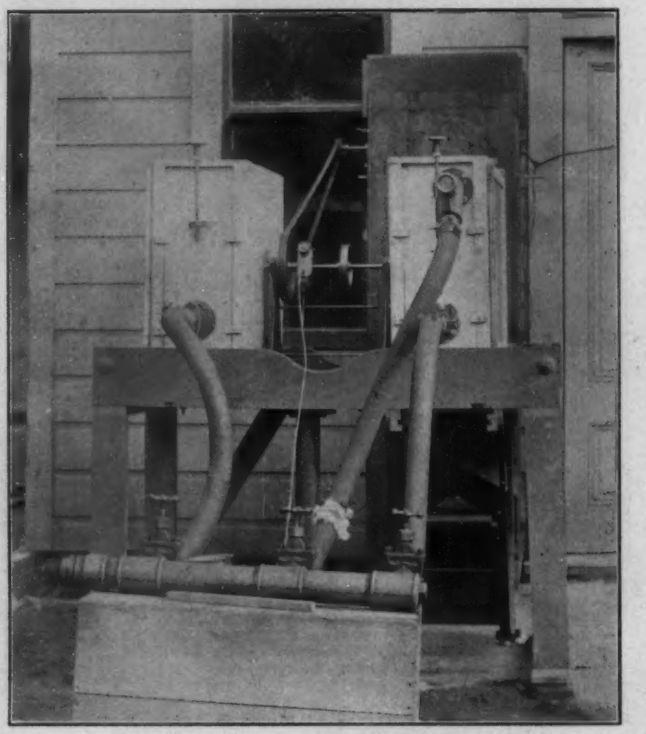
ONE OF THE PIECES OF EXPERIMENTAL APPARATUS AS USED IN THE INVESTIGATIONS, SHOWING THE ARC LIGHT AND SHUTTER FOR ILLUMINATION THE WHEEL AND NOZZLE ENCLOSED IN A PLATEGLASS CASE, PRONY BRAKE AND ACCESSORY MEASURING APPARATUS
[Patented, 1903, by George J. Henry, Jr.]

MR. GEO. J. HENRY, JR. My object in bringing up that point, more than anything else, was to explain the number of cases of apparently actual erosion not explainable by any other method. The Pelton water wheel buckets have been very often attacked on account of erratic erosion, not in any way due to the bucket curves, but to the entirely extraneous causes and effects, such as a distorted stream. I wanted to call the attention of the members to the fact that you have got to take into account every condition under which a water wheel bucket operates before you can justly determine the reasons for erosion on any given part of the bucket. I think that you will find in most cases of Pelton buckets, where they are running under correct conditions—conditions for which they were designed—that the erosion will not occur on the back, due to the discharge from the buckets, at any time. That, at any rate, is the result of my observation.

THE CHAIRMAN. I noticed, in the face of this bucket, on the

knife, a peculiar erosion at this point (showing.) Do you attribute that to chemical or mechanical effect?

MR. HENRY. I think most of the erosion which you will find on the wedge or the knife is mechanical erosion. As I stated before, every example that we can find of chemical erosion at all is combined so largely with mechanical erosion that it is hard to distinguish between the two. Usually, where you find a smooth surface and not a quantity of pits or wave forms, it is mechanical erosion, I think, and where the wave forms occur it usually originates from chemical erosion. I should consider these pits here to be formed by defects in the casting. In casting a bucket like this the thin splitter in the center usually gets chilled, and the small particles of sand or imperfections will rise to the splitting edge, especially in the old type of buckets. Where we wish to obtain the very best results and where the purchaser is willing to spend money enough on his wheels, we cast this wedge thick in order to get pure material in it, and then plane it down, so as to get rid of this otherwise mechanical erosion.



A FRONT VIEW OF THE EXPERIMENTAL APPARATUS AS EXHIBITED AT THE SAN RAFAEL CONVENTION
[Patented, 1903, by George J. Henry. Jr.]

THE CHAIRMAN. Have you noticed in water wheel buckets these same effects when you use metals other than iron or steel?

MR. HENRY. Yes. I showed you on the screen a bronze bucket from the Blue Lakes plant in which the erosion had started. That was was a bronze bucket. It is just as observable in bronze as in steel. The one particularly referred to is a cast iron bucket.

THE CHAIRMAN. The chemical erosion is just as pronounced.

MR. HENRY. Just the same; and this other is a cast steel bucket. I say it is just as pronounced. I don't know if the wheel were to be fitted with both, if the two would erode exactly the same. They might not. But the effect of both chemical and mechanical erosion seems to be apparent in both bronze and steel buckets, and the bronze does not seem to last much better than cast iron under ordinary conditions. We use steel or bronze buckets usually under high pressure, and we get better physical characteristics and better material in the small size bronze buckets and in the larger sizes of steel buckets.

THE CHAIRMAN. The reason I asked that question was, because in the case of the first water wheel runners put in the Folsom plant, the blades were made of bronze, the hubs and rims were cast around them, and the reason those wheels gave way was from the fact that in pouring cast iron around bronze the two metals did not unite sufficiently to make them strong. However, there being no erosion noticeable may be accounted for by the fact that the wheels did not stand up long enough to erode on the back of the blades.

MR. HENRY. In perfectly clear water we get practically no erosion. I saw a bucket in Nevada City a while ago which the man who was running the hoist said he had been operating himself for eighteen years. The buckets were of cast iron and the wheel had been operating under about a 300-foot head. The wedge was worn not over three-thirty-seconds of an inch, or just about as much as this is. The bucket was half this size and was just polished up nicely on the inside. There he had evidently perfectly pure water which was probably free from gases and chemicals in solution. I have a large bucket in the office that I would be glad to show any of you at any time that came from the Azusa ice plant. After operating about ten years the bucket is merely smoothed off here and there, and the inside is just as smooth as if it had been rubbed down with emery paper a little bit. The back is thickly coated with a lime deposit, there being a good deal of lime carried in the water, which is evidently very soft. We find many instances in practice in which there is no apparent erosion, at least not for long periods of time. I have a bucket also that came off of the Butte County plant, after running 15,000 hours, I believe it was, and was told that during that time there had been 12,000 tons of quartz tailings passed over it. Probably 30 per cent of the original paint is still observable in the bucket, which is not worn, and the paint that is still in there retains its original thickness. You can chip it out with a knife and you will find it to be as thick as a visiting card. It has scaled off apparently in some places, and the steel behind it is worn probably to twice the thickness of a visiting card, showing that the paint is the finest kind of a protecting coating. In large water wheels, where they have one spare unit or more, if they would make a regular practice of shutting down about the time the paint begins to wear off, and repaint the idle wheel, allowing it to dry thoroughly, they could prolong the life of most buckets indefinitely. This question of wearing of buckets in the average plant is not an important one. It is only in special cases where we find the water carrying cutting material, or chemicals in solution, and there the buckets will erode in anywhere from a few months to five or ten years.

MR. HUTTON. Another point that might be talked of a little bit is the question of the erosion on the inside of nozzles. At the last session one of the members—I believe it was Mr. Eastwood of Fresno—stated that after taking one of their old nozzles which was considerably eaten out on the inside, reboring it and lining it with babbitt, that the effect of the water did not seem to be as great as it was on iron. It occurred to me, therefore, that possibly you might galvanize your buckets and note some good effect from that. Have you tried that?

MR. HENRY. The Pelton Water Wheel Company made a number of experiments in the early days by coating buckets with rubber, but they could not make the rubber hold to the iron. It would come off. That was vulcanizing rubber right on the surface. That, I believe, would be a very valuable protection against wear if it could be made to hold. But, really, the question of bucket erosion is not, as I say, a sufficiently important one to warrant a purchaser in spending the additional amount of money, in most instances, to have any such coating on his buckets, because he can protect it so well by painting it, which is the cheapest kind of protection. We have a special quality of paint that practice has proved most satisfactory for that work. It gives a very rubbery and secure coating to the surface—one that does not come off very readily, and we have very little complaint from worn buckets.

THE CHAIRMAN. You have never tried galvanizing?

MR. HENRY. We have never tried galvanizing. I should think that that might be a very good idea. I should think that the ead nozzle that Mr. Eastwood spoke of, or the babbitted nozzle, if it was to exactly the same curves as the original cast iron or steel or bronze nozzle which he used, if the babbitted nozzle proved better it might be due to emery dust, or quartz sand in the water; in other words, the original erosion was probably mechanical erosion, and in that case the babbitt provided a soft surface on which the quartz sand would not cut.

THE CHAIRMAN. In the particular sample that he showed us the erosion seemed to be very similar to that in the nozzle you showed on the screen tonight.

MR. HENRY. Then the curves of the nozzle are not right, because, if you have that sudden change from the curvature of the nozzle to the straight bore of the nozzle, if there is a decided kink in that curve, there will be a tendency to form a vacuum at that point, and whether it is mechanical or chemical erosion, you will always get a cutting effect at that point. I don't know what Mr. Eastwood's babbitted nozzle was, but I expect that he took that corner off when he babbitted and probably got a better curve. In order to get any reliable results the two ought to be identical in the curvature.

THE CHAIRMAN. In making your nozzles now you make them with a curve on the inside?

MR. HENRY. The curve becomes tangential to the straight line, without any shoulder.

MR. VAN NORDEN. I would like to ask a question in connection with that. We were shown in one of the photographs where the air in solution in the water was quite apparent. Now it would go without saying that if it was so in one case, it must be so in the other case, that there would necessarily be air in the water, which, according to Mr. Henry's description, would give us what he calls chemical erosion. As a matter of fact, in a great many water wheels running, we don't have any of that at all, absolutely none of it. How would you account for the fact that it would come on some wheels and not on others?

MR. HENRY. I believe in a good many instances you will find that the water that is used over water wheel buckets which erode chemically or mechanically, or both, carries large quantities of mill tailings—very often chemicals in solution in sufficient quantity to cause an oxidizing effect. In other words, water is an oxidizing agent, unless it is pure mountain spring water. If the water just before being caught in the reservoir, for instance, runs over a water wheel, you will find that after it leaves the reservoir it will carry much more air in solution than if it runs along very gently for a long distance in a wooden pipe or a wooden flume. Water again running through an earthen ditch will gather enough chemicals in solution to cause some effect. I think that in this particular bucket, this style of bucket from the Santa Ana station, I think that in that water they have a small quantity of sulphurous or sulphuric acid. I don't mean a quantity—there is, probably, just a chemical trace—but enough to produce an oxidizing effect. It becomes an oxidizing agent in actual practice on the bucket.

Again in some long pipe lines you will find air charging chambers. In many cases you will find that the air in those charging chambers will be absorbed in the water, and they will have to recharge the chambers frequently, in some cases once in twenty-four hours, in other cases once a week; in still others the air will stay in there all the time without any apparent reason for the differences. Some of the waters used over water wheel buckets seem to have a capacity for taking up air in solution. I had one very interesting case came before my notice a few months ago. A party bought a pipe line from us and wrote afterward complaining that it was not tight. We wrote him for particulars, and we found out that he had used it for an inverted siphon, and he would charge it. It would start up very nicely and run for fifteen or twenty minutes, and then it would stop without any apparent reason, and he would find a big bubble in the top of his pipe. That, at least, was his complaint. We advised him to put a small vacuum pump on the top of his pipe, which he did, and to test the gas, and he found that the water carried a quantity of carbonic acid gas, which, at the top of the siphon, was drawn out of the water. Due to the negative pressure—due to the vacuum pressure—the gas collected there until a considerable bubble formed, and after that bubble formed the siphon stopped working. That is merely a case where water contained large quantities of carbonic acid gas. In this case I speak of, at the Azusa plant in southern California, the water carries large quantities of lime. There was lime deposited all over the back of the Pelton bucket in great nodules, in spite of the fact that the bucket was working all the time.

MR. A. J. BOWIE JR. I would like to ask if the curve on the back of the bucket, due to a cut-off nozzle leaking, is apt to be more serious than in front of the bucket, due to the action of the water, on account of the different angle at which it would strike.

MR. HENRY. That depends partly on the relative time during which the water would strike the back or the front. Take, for instance, the case of a plant where a man would have two wheels on the same shaft, running in the same case, and we will say that he is driving a very light day load and a very heavy peak load at night, the two wheels having a combined capacity for 50 per cent. overload. In a case like that he would probably run at 25 per cent. during the day. Three of his nozzles would be shut off, two on one wheel and one on the first wheel. One-fourth of the total water, or one jet, would then only carry his load for probably twenty hours in the day. In a case like that, if these old cut-offs—which were an old-style device, by the way, and not used always, but sometimes, in special cases—if three of them were cut off and the water carried sufficient grit to cut them out, or if they were not properly fitted—he might in a case like that get the bucket cut off in the back before any appreciable wear occurred on the front. That is a rare case. I have known it to happen in but two instances where the erosion on the back was very severe, due to cut-offs. One of them was at the Allison Ranch mine, and the other was at the Nevada County power house.

MR. BOWIE. Wouldn't it justify some steps to prevent the cut-off nozzle cutting off entirely to throw the water forward?

MR. HENRY. Certainly. They could put another shield over the nozzle to catch that water, or they could do a great deal better by putting on a new tip and a new cut-off hood. But it is a peculiarity of a good many power plants that when they once turn water on the water wheel, they let it run until something breaks. That, of course is rather hard on the whole equipment. It is a defective condition. No nozzle tip or cut-off hood should be allowed to run long enough or be so improperly adjusted as to permit such a discharge on the backs of the buckets.

MR. BOWIE. Is it possible to make a cut-off hood that will not leak?

MR. HENRY. Yes, indeed it is. I mean so that it will not leak appreciably. In shaping cut-off hoods and tips the tips are turned to the spherical radius the same as the cut-off hoods, and they are adjusted so they will shave off a piece of tissue paper when they leave the shop. They will not last long in gritty water. They should be replaced. They are a very cheap device and easy to replace.

THE CHAIRMAN. Mr. Doble, you have had considerable experience in the matter of the erosion of buckets. We would like to hear a few remarks from you?

MR. W. A. DOBLE. Mr. President. Being one of the inventors of water wheel buckets, of the class which Mr. Henry said crop like mushrooms over night after each rainstorm, I hardly feel competent to discuss his paper. There are one or two points, however, that I would like to call attention to, one being the form of the Pelton bucket (the two buckets on the table before you are typical Pelton buckets), the other being the shape of the so-called Pelton buckets shown you on the screen and exhibited in the glass case with the interrupted rays of light projected against

hem, both classified as Pelton buckets. Possibly Mr. Henry has so classified the latter out of modesty, bnt, as I remember, a patent issued in the name of George Henry Jr. for a water-wheel-bucket within the last month, namely, May 19, 1903, and it is the bucket described in this patent that Mr. Henry exhibited to you tonight in the diagrams projected on the screen and on the exhibition wheel, and not Pelton buckets, as Mr. Henry has stated. You will observe that the form of this bucket is a radical departure from that of the Pelton bucket, samples of which are on the table; and when I say radical I think I am justified, because in a device as simple apparently as the water-wheel bucket it does not take a great change to be a radical change, because it is a change in principle largely and affects the theory of the action of the bucket, the effect of the entrance of and passage of the bucket through the jet, and the theory of the flow of the water through the bucket and the place, direction and character of discharge from the bucket.

Even though some of us are mushrooms, sprung up, as it were, over night after a rainstorm, it is very interesting to note that the work of some of the mushrooms has had a decided effect upon higher development of the bucket of the tangential water wheel.

In support of this statement please refer to the diagrams purporting to represent the character of stream action in one of these Henryized Pelton buckets exhibited on the screen, also the buckets on the exhibition wheel. An examination of these will demonstrate that they are an exact reproduction of the bucket used by our company before we placed the ellipsoidal bucket on the market. In fact one of the steps in the evolution of the ellipsoidal bucket was the bucket, diagrams and models of which are now exhibited to you as Pelton buckets. The bucket referred to was designed by myself in 1896, and, as developed, patented in 1899. It was in this bucket that attention was first called to the losses in efficiency caused by eddy currents and whirlpool action in the water passing through the bucket and the irregular erosion of the hydraulic surface caused by this action, and, to overcome this, the large, rounded-end curves, furnishing reactive, curved-end faces, were introduced, thus avoiding the abrupt change in surface over which the water must flow in the Pelton bucket, and which abrupt change in the direction of flow necessarily causes eddy and whirlpool action and disturbances, attended by loss in efficiency, irregular erosion in tne hydraulic surfaces and the consequent losses.

Attention was called to the fact that buckets of the Pelton type did not discharge the maximum quantity of water over the sides, as they were supposed to do, and as their makers claimed they did, but that the maximum discharge was from the corners of the bucket, which was proved by the cutting out and irregular erosion of the buckets in the corners. That the Pelton Company realized this fault must be evident from their nicely rounded buckets which they recommend for your use this evening. So even a mushroom serves a useful purpose in the order of things. Of course, you all understand that to make an efficient wheel the designer must consider not only the proper form of the bucket, but also the proportioning of the parts with regard to the conditions to be met and the power output, the spacing of the buckets and the proper mechanical adjustment of the whole machine. If these other elements are disregarded, the result would be an utter failure of the wheel, even though equipped with a bucket of proper form. So that the results of an experiment may be fallacious, or easily distorted, by attributing to the bucket form a fault chargeable to any one of the several elements entering into the design of a proper wheel.

Now, with reference to the Pelton buckets on the table: examining the larger bucket, which Mr. Henry said was not eroded in the corners, and passing your fingers along the corners where the semi-cylinder curve section of the bowl of the bucket joins the straight back wall, you will find that a deep erosion has taken place. Possibly it was to avoid this that in the bucket exhibited to you on the screen Mr. Henry copied the large curved corners of our earlier buckets.

Now, you will admit that if the discharge of water took place at the sides of these Pelton buckets, this characteristic erosion could not have occurred; this is self-evident.

Mr. Henry stated that where the buckets wore in the corners it was because the wheel was overloaded. You gentlemen have had a great deal of experience in this line. All I can say is that it is surprising to note how many Pelton wheels are overloaded. On the back of this bucket it is marked that it was designed for a jet of a diameter of 4¼ inches. I have frequently been in the power plant where the wheels are installed from which this bucket was taken, and know that in the running of this plant they do not use jets as large as 4¼ inches. In fact Mr. Henry produces this bucket to show how they look when the wheel is not overloaded. Still in the corners we find the same telltale erosion.

I have examined many hundreds of these buckets, and find this erosion in a greater or less degree in all of them, and in one case I have in mind, where the buckets are designed for a 2-inch jet, and so marked, the largest jet that has ever been discharged against them is 1¾ inches; *i, e.*, the wheel was only carrying a load of 77 per cent. of what it was designed for. Still the buckets taken from these wheels showed the same characteristic erosions.

I regret entering on this phase of the discussion, and should not have done so but for the fact that I regard Mr. Henry's exhibition and conclusions as grossly deceptive. I might rest the case with notice of the fact that the ellipsoidal buckets used in his exhibition were not made by those experienced in designing and using that form of buckets, but by the Pelton Company, which is interested in proving it worthless. If made for the purpose of investigating the efficiency of the bucket by experienced and competent designers, the diagrams and models would have been different in several material particulars.

There is one point that I particularly desire to call your attention to, namely, in both buckets there is a common wedge in the center of the bucket. We all owe this feature to the Coleman bucket. There is no question about that. It long antedates the Pelton buckets. The first dividing wedge bucket on modern lines was designed by Professor Hesse, who furnished drawings thereof to the Risdon Iron Works some six years before Mr. Pelton conceived of his bucket.

In considering the character of flow of water through the buckets exhibited to you tonight, bear in mind that they both are provided with the dividing wedge of the Coleman and Hesse buckets. Mr. Henry states, and shows in the diagrams on the screen, that in the Pelton bucket the water flowing down the inclined surface of this wedge spreads out in a fan-like shape. In the diagrams of the ellipsoidal bucket, he states that water flowing down this same inclined surface comes together at a point, crosses over, making a whirlpool action at this point, and then spreads out. In both buckets the water flows down surfaces of the same general character. Now, if you will carry in your minds the diagram and note the section of water shown where the jet was being split on the dividing wedge of the bucket, also the cross-sectional area of this jet, then can you conceive how it would be possible that that quantity of water could pass the point of contraction at the bottom of the bucket, as indicated by Mr. Henry's diagram? I do not think that you can be made to believe that this contraction can possibly take place. The velocity in the water flowing through the bucket cannot be any greater than the velocity of the jet where it is first divided on the splitting wedge in the bucket, and as the same quantity of water, as indicated where the jet enters the bucket, must also pass the point "A" at the bottom of the bucket, where he indicates that these lines are crossed and turned over, it would require a great acceleration to force the same quantity of water to pass the point, or the wall of water would have built up to an impossible height. Do you think Mr. Henry really believes that the water acts in this way?

There can be no question but the same erosion exists in this bucket from the wheel which was not overloaded, as Mr. Henry admits appears in the other buckets. Your eyes and your fingers

furnish unmistakable evidence of that fact. What then is the true explanation? Is it not natural that the water, taking Mr. Henry's own diagram, after striking against the inside surface of the inclined outer end or lip of the bucket, should shoot across the bucket and impinge against the inner surface of the inclined back wall, and be diverted against the back of the next bucket following? It is a simple matter, which you can readily follow out for yourselves. It is also surprising that as such a large quantity of water used on the ellipsoidal bucket passes through the cut-out in the bucket, as stated by Mr. Henry, and thereby goes to waste, the ellipsoidal wheels should have done so well, and so many ellipsoidal buckets should have replaced Pelton buckets in various power plants on the coast, and those who operate them should think that they are getting more power and higher efficiency and longer lived buckets?

In one of the slides exhibited to you this evening, showing the outer end of a bucket, Mr. Henry stated that no erosion had taken place on the outer surface of the entrance lip of the bucket. This must have been an oversight, because on examining the photograph considerable erosion is very clear on the outside surface of the entrance lip of this bucket, caused by slapping on the jet. It can be noted very clearly on the photograph.

There is another point: Take note of the thickness of the metal in this bucket, which is exhibited to you, in the entrance lip and that part which passes through the jet. That part which passes through the jet is by actual measurement a little over a quarter of an inch thick. The markings on the back of this bucket indicate that there were thirty-eight buckets on the wheel, and as the wheel was operating at about sixty revolutions per minute, that makes 2300 times per minute that this lip, over one-quarter inch thick, was forced through the jet, and 2300 times per minute that the entrance lip of this bucket struck on the top of the jet. Now is it reasonable to suppose that the lip striking the jet and forcing through the jet to the tune of 2300 times a minute should not affect the condition of the jet?

There is another point to consider with reference to the value of the entrance lip on a bucket: These buckets show erosion on the outer surface of the entrance lip. They show practically no erosion on the inner surface of the entrance lip. Therefore there must have been a loss of energy in diverting from the bucket this water which was doing its best to get inside of the bucket. The buckets are here. They speak for themselves.

It is good to have more than one active water-wheel builder competing for business; it naturally develops the machine. I think few of our people appreciated up to a few years ago the value of first-class machinery. The very fact that Mr. George Henry Jr., the chief engineer of the Pelton Water Wheel Company, has recently taken out a patent on an improved form of bucket (presumably better than the Pelton bucket) would seem to show that the Pelton bucket is not beyond improvement. When you further compare the shape of the new so-called Pelton buckets, exhibited by Mr. Henry, with the real Pelton buckets, also exhibited, you will note an entire change in form, the length having been increased in proportion to the width and the corners having been filled in with round, large, curved, reactive-end faces. Take his new bucket and cut an opening through the entrance lip, and presto! you have the Doble bucket. In fact, as I stated before, the bucket that has been patented by Mr. Henry is one of our earlier buckets, which we have laid on the shelf.

Now, consider the diagram, which Mr. Henry has made of an ellipsoidal bucket, and the photograph showing the node at some distance abaft the bucket. I have always contended that when Mr. Pelton designed the Pelton wheel, or rather when Professor Hesse designed it, he considered the bucket in but one position in relation to the jet, which is equivalent to designing a wheel to stand still; and, really, you know, when power companies buy water-wheels they do not buy them to stand still. When the wheel is running and the buckets and water traveling at their proper relative speed, the node, on which Mr. Henry has so strongly dwelled, does not form, it cannot exist, nor does the discharge occur as it has been illustrated.

With reference to the diagrams showing the ellipsoidal buckets, those diagrams simply indicate that they were not properly made; further, that the maker of the diagrams did not, if he understood the subject, use his knowledge in this work. Had they been properly made and properly proportioned to the jet, the characteristics shown would not have occurred, and they do not occur in wheels in service. The experiments, which Mr. Henry has shown us with the small wheels and the flashlights, are very interesting, and I think this association is indebted to Mr. Henry for bringing before us an ingenious and most interesting exhibit. When we recall the wonderful feats of prestidigitators solely through the instrumentality of flashlights and reflectors, we cannot but feel that a mechanical experiment, in which they play such important parts, is at least subject to the criticism that it is conducive of optical delusions. Is not that criticism applicable here? When the buckets and the water were traveling at the same speed, it had all of the appearances, as Mr. Henry put it, of the water passing through as if there were holes in the buckets, and, by the way, he was not then using an ellipsoidal bucket. When the buckets were traveling slightly faster than the water—a condition, of course, never present in practice—the discharge appeared to be perfect, the water being driven clear of the wheel by the backs of the buckets, and never touching the working faces.

You were shown, both on the screen and on the exhibition model, a Henry (not a Pelton) bucket discharging, as its inventor told you, to the best advantage—a perfect demonstration! But to our astonishment, when the other lights were turned on, we found that our eyes were deceiving us, for the wheel was not running up to proper speed, as was clearly shown (when the lights were turned on so as to illuminate the entire case) by the strong backward discharge. I am sure we were all surprised, upon seeing the whole apparatus, to ascertain that the wheel, the discharge of which we were observing, was not being driven by the water projected against its buckets, but by the innocent little wheel on the other end of the same shaft. Can any scientific importance be attached to such an exhibition? Is it not apparent that in this way it could be clearly demonstrated (by a proper manipulation of the apparatus) that any bucket would discharge in any old way that the manipulator desired? Of course, I wish to say nothing in derrogation of the scenic effects of Mr. Henry's exhibition, which, I am sure, we all enjoyed.

Again referring to the photographs projected on the screen, you will remember a photograph of a stationary Pelton wheel with a perfect fan-like discharge of water; but take note that to secure this discharge Mr. Henry removed two of the buckets from the wheel in advance of the one against which the jet was projecting, so as to prevent these buckets interfering with the jet, as they would in service.

There is one other point that I would mention: Mr. Henry has exhibited photographs of an ellipsoidal wheel at the Mill Creek No. 3 station of The Edison Electric Company, operating under 1900-foot effective head. He painted the inner surface of the buckets with japan to show the wear in the buckets by the wearing off of the japan coating after a run of seven hours. I presume that Mr. Henry was not aware of the fact that the nozzle on this unit was set low and out of place at the time he made this experiment. The buckets of the ellipsoidal type in service exhibit a different wear, and, as they have been running for some years, our observations as to their wear must be of greater value than a seven-hours' wearing test with a bucket freshly coated with japan.

The Mill Creek plant, in which is installed the ellipsoidal bucket photographed by Mr. Henry, is a very interesting one, the unit being under over 1900-foot effective head and of large size, namely, 750 kilowatts, so that the wheel is of sufficient power to give object lessons. As this wheel has driven the generator to a point where it was delivering 1200 kilowatts of commercial electrical energy to the transmission line, observations from it must

be of more importance than an exhibition of a twelve-inch wheel which was being turned by its silent partner, a second wheel on the dark end of the shaft.

The contract for this Mill Creek No. 3 plant was placed on the understanding that, as the power company proposed to buy further wheels, the two wheels first ordered would demonstrate the relative values of the wheels made by the different companies. The plant was designed to consist of four wheel units of 750 kilowatts capacity with water wheels designed to drive the generators at a 25 per cent. overload at a turning speed of 430 revolutions per minute. Therefore they ordered two wheel units at first, one from the Pelton Water Wheel Company and one from the Abner Doble Company, taking an option from each company for two additional wheel units with the agreement that they would place the balance of the order with the concern producing the best and most satisfactory unit. These wheels have been running for some time, and the contract for the other two units has been placed with the Abner Doble Company. This is one of the cases where he who runs may read.

I regret that I have been led to discuss these matters on this occasion, for I do not consider a meeting of a scientific society the proper place for a manufacturer to advertise his products. We are here to give each other the benefits of our investigations and experiences on matters of common interest, and not to act as drummers, but it was impossible to lend the apparent sanction of silence to an avowed attack on my inventions in the interest of a business rival. Having seen that these exhibits did not truly show the characteristics or the work of the ellipsoidal bucket, and that in preparing these diagrams the bucket instead of being passed through the jet in its true path was merely tipped forward, so that at no time was the jet really within the bucket, and the wheel exhibited was not of proper design, or construction, and was not running at the proper speed, I determined that as these subjects of business rivalry were to be discussed, I would at least endeavor to present them in their true light.

MR. HENRY. There are several points mentioned by Mr. Doble that I would like to say another word or two about. I don't know whether I made myself sufficiently clear in regard to the way all Pelton buckets are supposed to be designed. The Pelton Company does not build its buckets on one particular pattern, but on dozens of patterns. We own a great many different patents, and we use these patents separarely or collectively in designing our buckets for any given condition, with a view to attaining the best possible results under those specific conditions. You will find, probably, an entirely different shape of bucket on the next wheel we build for this same head and wheel diameter, due to changes in the size of the nozzle and in the speed. We don't attempt to hold to one particular bucket shape. We do, however, make the claim broadly that every bucket should have a line bottom instead of a deepest-point bottom. I don't think Mr. Doble gathered my meaning in regard to the tendency of lines of water pressure crossing on the deepest point. I did not say that they all crossed at that point, but that there was a tendency for them to cross, and, consequently, a crowding on the deepest point, resulting in eddy currents and a loss of energy and a greater wear there. It was perfectly obvious to all of you that the water could not all cross on a point without attaining an infinite velocity, which is absolutely impossible. All it can do is to pile up together in one mass in the bottom and be pushed out of the way by the water following. Some of the buckets that I have seen of ellipsoidal design—I think some that he has illustrated in times gone by—have shown a worn spot in the deepest point, which, if I remember rightly, was explained as being a soft spot in the casting, due to the lug behind, shrinkage in the quantity of metal at that point. I think that he is mistaken in regard to that. I think you will find that the deepest point in the bucket is worn deeper, worn faster than the rest of the bucket.

One more point in regard to the Mill Creek No. 3 station. Mr. Doble stated that The Edison Electric Company took an option from both water wheel concerns. I appreciate the fact that Mr. Doble was speaking from his standpoint entirely in regard to that The Pelton Water Wheel Company never gave The Edison Electric Company an option on two additional units. They never signed a contract with them for the water wheels; they never agreed to build a water wheel for 25 per cent. overload. On the contrary, we were asked for a water wheel from 15 to 17 per cent. overload capacity. We built them a wheel for 50 per cent. overload capacity whenever they want to put on a nozzle that will give them 50 per cent. overload capacity. In regard to the ellipsoidal buckets which I threw on the screen and which had been painted with asphaltum varnish at the Mill Creek No. 3 station I was very careful to see that the nozzle was not too low and that it was in a position of maximum efficiency. If you will all study this photograph as it will appear in your transactions, and as I can show it to you now, you will note that the asphaltum varnish is worn from the bucket at the top of the dividing wedge—the flat portion of the bucket where the dividing wedge joins to the back of the bucket; showing clearly that the stream even cut the back of the bucket where it joins to the wheel. I was very careful to see that we did have a proper setting before we made such experiment, out of justice to Mr. Doble. We wished to get the best results which his bucket would show.

In regard to the claim that the apparatus which I have shown you, and the types of buckets which I have shown you, do not give the actual discharges as they occur in an operating wheel, I would say in regard to this that I should like very much to have heard from Mr. Doble when I was exhibiting the apparatus; I would have been very glad to have readjusted the nozzle, as I stated at the time in his presence, either in size or position, or to readjust the speed of the wheel so that he would have been satisfied that it was giving the best results. I appreciate the fact that I have not designed many ellipsoidal wheels; only those that we have used for experimental purposes ourselves; but in the particular wheel which I showed you experimentally, its bucket was designed from an authentic drawing for ellipsoidal buckets. It is as near as I could design an ellipsoidal bucket, because I was desirous of obtaining the best results obtainable from the ellipsoidal buckets and the photograph of the buckets used speaks for itself.

We have not heard anything in regard to the actual efficiencies obtained on the ellipsoidal bucket, so far as I know. I would like to gather some data on that subject.

One more remark, and that is in regard to the Henry bucket that Mr. Doble was good enough to mention. The Henry bucket has the line bottom, has the dividing wedge and it has rounder corners than you find in this bucket; much rounder corners; but it is one of the Pelton patents, and you will not find that it is used to the exclusion of the Pelton bucket by any means.

I don't think that Mr. Doble's conclusion in regard to the exhibits before him was quite just. I don't think that you will find any unusual wear in these corners. You will find some wear yes. I did not make the statment that these buckets were not overloaded. On the contrary, they may have been overloaded. They are very nearly correctly loaded, and if they were overloaded they were very slightly overloaded.

There is one thing more, and that is this large steel bucket from the Santa Ana station. You will find paint on the back and front edges—the original paint as it left the factory. The order for the Doble wheels which was placed by The Edison Company was placed before any tests were ever made on either of the water wheels in their station, and was not the result of any option or overload capacity, or anything of that sort, as far as the Pelton Company is cognizant.

MR. DOBLE. The statement just made by Mr. Henry I should like to correct. The order for the last unit for the Mill Creek No. 3 plant is of very recent date, having been placed with our company after the plant had been running for some time and after they had had sufficient experience with both the Pelton and Doble units.

There is a little point which I should like to speak about,

namely, the one of erosion of surfaces, and it was on this subject that I had intended to speak to you this evening, not expecting a paper to be presented such as has been read. The micro-structure of the material itself has a great influence on the erosion, as was discovered by Dr, Dudley, chemist and chief of the testing department of the Pennsylvania Railroad, particularly in his experiments on journals and car-brasses, and he found that the difference in alloys and their wearing qualities was largely influenced by the micro-structure of the material, so much so that by experimenting with very cheap alloys he has been able to produce the same structure and the wearing qualities of the car-brasses, making a great saving to the railroad company. The structure of the material is one that is very interesting in this connection and is of the utmost importance in the wearing qualities. I hope at some other meeting to bring this more fully to your attention.

In closing I should like to call your attention to the statement made by Mr. Eastwood at the last meeting of the Association in San Francisco, in which he called attention to the power plant being installed in Switzerland under a head of approximately 3000 feet. This wheel unit is of the tangential type and was designed and built by the Mechanical Construction Company of Vevey for the Vouvry Hydraulic Power Plant. The wheels have been completely installed, and under test showed an efficiency of only 56 per cent., whereas the wheels installed in the Mill Creek No. 3 plant of the Edison Electric Company under over 1900 feet effective head show an efficiency of 85 per cent. This will indicate that it is not necessary for our California power companies to go abroad for tangential water wheels.

THE CHAIRMAN. What, to-day, is considered by the manufacturers as being the limit of high pressure wheels?

MR. HENRY. So far as I am concerned, I think it would depened very largely on the size of the stream necessary to use, and the material available in the market. We use on high-head water wheels open-hearth flanged steel plates, rolled steel plates or discs. The rolling process leaves them free from shrinkage strains, and they are then bolted on to cast iron hubs and the buckets fitted to the outer rim. We have been getting a rolled material free from all blow holes and shrinkage and get a maximum strength in the rim of the wheel. We used nickle steel bolts for connecting cast steel annealed buckets to the wheel rim. We would not have the slightest hesitancy in building a water wheel for any ordinary sized unit, say up to 5000 horse power, under 3000-foot head. We are building today three 750-kilowatt units for 2100-foot heads.

THE CHAIRMAN. Single wheels?

MR. HENRY. Single wheels, with an absolute guarantee that they will withstand double the normal speed or the largest sized jets when the wheel is locked in position, without danger or damage. In the Pelton buckets in the Mill Creek No. 3 station the front bolts of the buckets are required to withstand a strain, if my memory serves me right, of 23,000 pounds. So you will see we are dealing with very considerable strains in high pressure design. The impact occurs 430 times a minute.

THE. CHAIRMAN. Would there be any advantage when building a wheel for such high heads, in decreasing the size of the nozzle, using more streams for instance, in order to distribute the impact?

MR. HENRY. There might be cases where that would be very advantageous. I should think that would particularly apply to high speed generators of steam turbine type, where we could use a wheel rotating in a horizontal plane on a vertical shaft, and use two jets from opposite sides, in that way balancing the thrust, giving a pure torsion strain on the shaft. I should think there would be a very decided advantage in that way. There are other considerations. If our wheel diameter is very small, moving at very high speed, it is then very difficult to put buckets which will take a large stream on that small hub. The ratio of wheel diameter is the guiding factor in most of the high-head water wheel construction for getting the best results at high speed.

We are building four 3500-kilowatt units for the Guanajuato Power Company. The Columbia Improvement plant will operate under an 850-foot head. The buckets in that case are about twenty-four inches wide. The streams will be something over seven inches in diameter.

THE CHAIRMAN. You would consider that it would be advisable to consider this proposition: In utilizing a high head, instead of installing one power house, would any gain be made in efficiency by installing two power houses, thus using the double drop and utilizing about one-half of the total head?

MR. HENRY. I would hardly consider that. No; as far as water wheels are concerned, I don't believe it would make any material difference?

THE CHAIRMAN. You then think you could get an efficiency pretty nearly as good using the total head in one power house as you could with two power houses, dividing the head between them?

MR. HENRY. Yes, I think it would be almost entirely a question of the cost of another pipe line and the safety of the plant. The pipe line would be very expensive. If you attempted to use all the 2000-foot head you would have all your eggs in one basket, and if you were going to put in several generators, they might just as well be segregated in two plants. That has actually been done in a plant in Colorado. They have a head of 2000 feet. They built their first station for 1100 feet and have not built the second, but subdivided the head of 2200 feet in two parts. That is another advantage. One does not have to over-install, to start in with, and have an expensive pipe line lying idle for a long time.

One point more, and that is in regard to the efficiency of that Mill Creek No. 3 station. I don't know what efficiency the ellipsoidal buckets gave in Mr. Doble's test down there. There have been no official comparative tests made at the station. I was very much in hopes that Mr. Sinclair and Mr. Ensign would be here today, and that they would tell us something about that plant. I know we are all of us interested in the comparative results obtainable down here. I will state this, however, that Professor I,e Conte of the University of California made some tests on the Pelton wheel at Mill Creek No. 3 station, and reported to us that our wheel was developing an efficiency of 86.2 per cent. under a 1923-foot hood when running a 750-kilowatt generator at full load. That is the summary of his test. I don't know whether that is the result of our wheel, and I think we have cause to be very well satisfied. That includes all the losses in the gate and nozzle and the wheel. We propose to further increase that efficiency by putting on a larger nozzle and making some other changes. The plant is still in an experimental condition, as far as the Pelton wheels are concerned. I think they are running regularly, perhaps overloaded, if they wish it. The wheel has an overload capacity. But we are taking advantage of The Edison Company's kind offer and courtesy in placing their plant and their instruments at our disposal, to perfect several little features in our apparatus, and get the best possible results.

MR. RAY. When you put paint in the buckets, how long do you expect it to last before it commences to cut into the metal?

MR. HENRY. I have seen buckets that after they had been running about there years under a head of over 500 feet with the paint as good as when it was new. That is, however, a rare case. In some cases they seem to be scoured out very quickly. It depends entirely on the condition of the water and how they were painted in the first place, whether the buckets were properly cleaned before the paint was applied; whether the paint makes a close-holding rubbery surface. We put the paint on with a regular paint brush and allow it to dry and get hard, and then apply a second coat, and maybe a third. It is a question of making the paint stick to the bucket more than anything else. The paint, when it comes off, seems to come off in flakes or scales.

[Adjourned].

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EDITORIAL.

WORLD'S FAIR ELECTRICAL CONVENTION.

The managers of the World's Fair, to be held in St. Louis in 1904, have made arrangements for the holding of an International Electrical Congress to be held during the week of September 12th to 17th, 1904, and in connection with this Congress a number of prominent electrical societies are arranging to hold their convention in St. Louis during that week.

The Pacific Coast Electric Transmission Association has been invited to join with the American Institute of Electrical Engineers, the National Electric Light Association, the Electric Chemical Society, the Association of Edison's Illuminating Company and the Electric Therapeutic Association.

The plan for the Congress will include three branches —a chamber of delegates to be appointed by various governments, the main body of the Congress to be divided into sections, and conventions of the various electrical associations to be held simultaneously with the Congress. The scope of the proposed Congress will be more influential than any electrical Congress heretofore held, and its transactions will form probably the most important publication in the electrical field ever issued.

The Pacific Coast through the Transmission Association will undoubtedly be well represented, and it is among the possibilities that the annual convention of this society may be postponed from the regular June meeting so that it may be held in St. Louis at the time designated.

It goes without saying that most of the members of the Pacific Coast Electric Transmission Association will visit St. Louis during the holding of the World's Fair, and by some concerted action it might be made convenient for the members to arrange to be in St. Louis in a body at the time the Congress is held. If such a result could be obtained, the lasting benefit to California would be incalculable.

THE NORTH SHORE THIRD RAIL SYSTEM.

With the opening and the successful operation of the third rail system of the North Shore road between Sausalito and Mill Valley, the following remarks of the *Street Railway Review*, of August 20th, are most pertinent:

Since the introduction of electric traction the overhead trolley has held its own against all other methods for conducting the current from the power house to the cars along the line, and while the underground conduit has found favor in a very few large cities, where the density of traffic is sufficient to warrant the enormous outlay required for this construction, the third rail system is the only one which gives promise of interfering with the monopoly of the single overhead trolley. The third rail system comes as the result of the use of larger cars, or of trains, and higher speeds, and its use has largely increased during the last year or two.

On interurban and long distance railways where competition with steam road service requires the use of heavy trains at high speed a point is soon reached where the overhead trolley wire and wheel have not contact area sufficient to transmit the current required, and a trolley wheel cannot be used more than a few days before being ruined because of arcing. The third rail system has been found to fill every requirement satisfactorily up to any speed which it has been possible to attain, and for this reason it is likely to come into very extensive use as the development of long distance electric lines increases. There are many roads, however, on which either the overhead trolley or the third rail system would meet the requirements of the service, and on such roads the relative advantages and disadvantages of the third rail and trolley construction are important. From the standpoints of convenience of operation, safety and speed the third rail system has been found to be entirely satisfactory. The multiple unit system of control is in successful use on many of our elevated railroads handling enormous crowds daily without the slightest trouble or interruption to traffic, and the third rail shoes operate for long periods of time without renewal and at any speed desirable without serious arcing. The question of safety to the general public hardly arises, as all third rail construction must be on private right of way which should be fenced in so that the public does not have access to it, and there is apparently no more danger to passengers from the third rail than from the trolley wire, if there is as much, because a broken trolley wire might come in contact with a passenger while a third rail never could except through trespassing on the roadway.

A number of important questions in regard to the details of third rail construction are considered in an interesting article by L. E. Gould, electrical engineer of the Sterling, Dixon and Eastern Electric Railway. The section and chemical composition of the conductor rails, kinds of insulators, methods of bonding, method of making feeder taps, arrangement of special work, road crossings, contact shoes and other important details of third rail work are fully reviewed by Mr. Gould. The difficulty of keeping the conductor rail free from snow and sleet has been discussed considerably at times, and has perhaps been magnified to a greater extent than is justified by facts. The simplest way to avoid this trouble is to keep the cars moving, which means that with a short headway little trouble from this cause will be experienced. It is only on roads having a long headway where this trouble is at all serious, and it may be readily overcome by the use of sleet cutters of

various kinds. On the elevated roads of Chicago and Boston practically no delay is ever occasioned from this source, and the trouble which occurred one morning last winter on the New York elevated roads took place when the roads were first run by electricity and before the cars had been equipped with sleet cutting devices.

It is significant that there has been but little change in the character of third rail construction since this system was first installed, with the exception of the improvement in the insulation of the conductor rails and fittings.

The difficulty mentioned by Mr. Gould of keeping the conductor rail free from snow and sleet, is one that our climate beneficently obviates, and the use of sleet cutters on the North Shore will be one of the equipment expenses which will not have to be borne.

It may be said here, without fear of contradiction, that no third rail system in the United States is superior in of point equipment or construction to the North Shore, the many safeguards introduced for the protection of the road and public by the managers, are such as to reflect creditably, not only upon the engineers, but the capitalists controlling this system.

On October 1st the road to San Rafael will be completed and trains in operation, a consummation which every resident of San Rafael is looking forward to with relief.

THE UNITED RAILROADS.

On September 7th the United Railroads opened its through service to San Mateo with its new equipment. A half-hourly service has been put into vogue from the corner of Fifth and Market streets, and the possibilities are that the cars will hereafter be operated on a fifteen minute headway.

Both generating units are now in operation at the new electrical power house at North Beach, giving the company, for the first time in several years, a surplus of power. The new rotary transformer at the Geneva Street substation will be ready for use in about six weeks, and at the present time the Carl Street power station is shut down and held in reserve, leaving but two generating stations in operation, the North Beach plant and the one at Eleventh and Bryant streets.

The convention souvenir of the *Street Railway Review* of Chicago, issued August 20th, is without question the most magnificent trade journal yet put forth in the United States, and the readers as well as the publishers are to be congratulated upon its production. It is very seldom that a cover page containing advertisements can be brought to any high artistic value, but the *Street Railway Review* comes out with a most artistic design in which the advertisements appear to much advantage.

WATER WHEEL CONTRACT.

THE contract for supplying water wheels for the City of Seattle Municipal Lighting and Power Plant, has been awarded the Pelton Water Wheel Company of San Francisco. The main wheel units will be two in number, each direct connected to a 1200-kilowatt, 400 revolutions per minute, 2300-volt, sixty-cycle, three-phase, alternating-current, revolving field generator. The wheel units will operate under an effective head of about 550 feet and will have a capacity sufficient to develop 50 per cent. overload in each generator. Combination needle and deflecting nozzles will be employed for regulating wheels, the needle portion to be hand controlled while Lombard governors will handle the deflecting portion. Governors will be equipped with 125-volt motors to permit of central control of the main machines from switchboard.

Two seventy-five-kilowatt, 125-volt, compound wound multipolar direct-current generators will furnish exciting current. Each of these machines will be direct-connected to a Pelton wheel running 550 revolutions per minute.

A riveted steel pipe line of uniform diameter of forty-eight inches will lead the water a distance of about 1080 feet from the main penstock, the pipe varying in thickness from three-eighths to eleven-sixteenths inches, terminating in a steel receiver, from which, branch pipes will distribute the water to the various wheels.

The transmission line into Seattle will be approximately forty miles long, over two separate lines of three No. 1 copper wires or equivalent aluminum wires. The current at Seattle will be stepped down to two-phase at 2200 volts for city distribution for power, incandescent lighting, arc and series incandescent street lighting, through constant current transformers.

Owing to the season being so far advanced, it is the intention to complete and get into operation one of the transmission lines at once, the other to be erected as soon thereafter as possible.

ITEMS OF INTEREST.

LOS ANGELES RAILWAY.

C. O. Anderson has been appointed superintendent of line construction of the Los Angeles Railway Company. He will report to General Manager Muir. Mr. Anderson has been in the employ of the Los Angeles Traction Company.

OAKLAND TRANSIT.

The gross passenger earnings of the Oakland Transit Consolidated street railway system for the month of August, 1903, were $97,950.14; August, 1902, $83,638.84; increase over 1902, $14,311.30. The largest day's receipts amounted to $4,354.10 on August 16th.

WATSONVILLE TRANSPORTATION.

Sidney Sprout, electrical engineer, has gone to Watsonville on business connected with the Watsonville Transportation Company which is to open its electric road connecting with steamers for San Francisco in about one month. The company will install an electric power plant.

CALIFORNIA GAS AND ELECTRIC CORPORATION.

This company is increasing the capacity of the Santa Rosa gas works from 100,000 to 300,000 feet daily. A new oil gas-generating system is being installed, also a large steam compressor for pumping the gas to Petaluma. It is said that gas sales in the latter place are now twice as large as when the plant was purchased.

PACIFIC ELECTRIC.

Through the resignation of Charles E. Donnatin, superintendent of the mechanical department of the Pacific Electric Railroad Company of Los Angeles, which took effect the first of this month, Howard E. Huntington has been formally placed at the head of that department and will be known as "superintendent of electrical construction."

A CHANGE IN OWNERSHIP.

The Walla Walla Gas and Electric Company has sold its plant to Isaac W. Anderson of Spokane and associates in Philadelphia. The new owners propose to create 4000 horsepower. The plant at Pendleton was also purchased by Mr. Anderson, and the new owners contemplate furnishing power to all towns and intermediate points between Walla Walla and Pendleton. It is proposed to expend at least $250,000 in the extension of the property in the vicinity of Walla Walla, and it is thought work will commence very soon.

AMERICAN RIVER ELECTRIC.

W. H. Dean, formerly assistant superintendent and engineer of the Independent, has taken up his residence in Stockton to superintend construction work for this company in that city. Some weeks ago the company shipped some poles to Stockton and of late another consignment has arrived, while it is said that there are several more cars en route to Stockton. Construction is to be commenced out of Stockton at once. The poles will be placed in position over the route the Board of Supervisors recently granted a franchise and quite a force of men are to be put to work. The line will run in the most direct or shortest route to San Andreas and along the Mother Lode to Placer County, where the company is constructing a large dam.

CALIFORNIA GAS AND ELECTRIC CORPORATION.

The statement of earnings for the month of July, 1903, is as follows:

Gross earnings	$213,473.47
Operating, maintenance and taxes	127,503.46
Net profit	$85,970.01
Interest on underlying bonds	32,115.82
	$53,854.19
Interest on corporation bonds	33,333.33
Surplus	$20,520.86

STANDARD ELECTRIC COMPANY.

The United Gas and Electric Company and the Standard Electric Company are again occupying offices together in this city, and the two companies will be under one management in San Jose and the counties south of San Francisco, with Chester H. Pennoyer as district superintendent of both corporations. The United Company's new brick gas-house in San Jose is completed, ready for the new gas-generating sets which are about to be shipped. The completed portions of the company's new gas system covering many miles of Santa Clara and San Mateo counties, as well as the city of San Jose, are giving entire satisfaction. The new Saratoga electric railroad will be operated by current from the Standard transmission line, distributed through the United system. J. E. Green is at the head of the United Gas and Electric Company's management.

SAN FRANCISCO GAS AND ELECTRIC.

A 5-per-cent dividend is expected, commencing in December. Stockholders of the company have received a letter from the board of directors asking for their proxy, and stating unless unforeseen complication should arise the shareholders may expect a dividend to be declared by this company in December, and thereafter it is confidently believed that the business of the company will justify the declaration of regular dividends quarterly. On the completion of the proposed bond issue the company will absorb the assets and business of the following companies: Independent Gas and Power Company, Independent Electric Light and Power Company, Equitable Gas Light Company and Pacific Gas Improvement Company.

Owing to the policy of the board of directors in exercising severe retrenchment, in suspending dividends and in following the general line of policy as outlined in its annual report, it will be possible to capitalize the acquired companies on the books of the company at not over the actual costs of said companies as shown by their books.

When the bond issue shall have been made, the stock held by the Mercantile Trust Company of San Francisco under the pooling agreement will be returned to the shareholders on surrender of the trustees' certificates.

The meeting of shareholders is to be held at its offices, 415 Post Street, Thursday, October 22d, for the purpose of acting upon a voting proposition to create a bonded indebtedness of $10,000,000 for the purpose of paying for the properties recently acquired.

THE OPERATION OF A GAS WORKS.*

BY W. A. BAEHR.

This paper must necessarily be confined to an outline only of the processes employed today in a gas plant. In order to consider these logically, I will group the subjects under the following heads: Coal Gas Manufacture, Water Gas Manufacture, The Station Meter, Storage, Photometry and Calorimetry Usual Simple Tests for Purity, The Governor and Residuals.

COAL GAS MANUFACTURE.

The usual method of coal gas manufacture in the United States is by means of horizontal retorts, which in the larger and more modern plants are charged and the coke drawn by machinery. There are also some installations of inclined retorts in this country, together with a few in contemplation. I do not care to enter into the relative merits of inclines and horizontals; suffice it to say that the new coal gas plant of the Milwaukee Gas Light Company is designed to use horizontal retorts with com plete drawing, charging and coal handling machinery, and this decision was reached by the engineers of that large establishment after a most painstaking comparison of the merits of the two systems. They found that in the case of Milwaukee the horizontals with machinery showed a saving of many thousands of dollars per year over the inclines.

I will describe briefly a recuperative full-depth bench of six retorts each. These retorts are usually rhombus-shaped, open at one end only, and about 16 by 26 inches by 9 to 10 feet long. In the case of full-depth benches, they are charged and the coke drawn from the operating floor, which is usually from 9 to 12 feet above the cellar floor. The heat required to carbonize the coal is derived as follows:

A deep furnace at the bottom of the setting is filled with coke heated to incandescence. Through this incandescent fuel bed a moderate amount of air is admitted, called the primary air. The inlet is so gauged that all the oxygen of the primary air is converted into carbonic oxide as follows:

$$C+2O=CO_2$$
$$CO_2+C=2CO$$

That is, the carbon at the bottom of the fire is first burned to CO_2, and this in turn, by passing up through the incandescent fuel bed, is converted into CO. The nitrogen of course merely passes up, and is heated to the temperature of the fire.

Now this CO, mingled with nitrogen, passes up through a furnace arch into the combustion chamber situated just below the lower retorts. On the sides of this chamber are several nostrils from which issue streams of secondary air, which has passed up through the recuperators on each side of the furnace, and thus become heated.

The producer gas from the furnaces, on meeting this secondary air, burns to CO_2 around the retorts, heating them intensely. The waste gases pass down through the recuperators, giving off a portion of their sensible heat to the incoming secondary air. The formation of clinkers in the lower part of the furnaces is prevented by introducing water in the ash pan, and also by water falling from drip plates at the front.

The heat reactions taking place can be briefly described by saying that each pound of carbon converted to CO in the furnace requires 5.77 pounds of air, and the CO thus formed requires another 5.77 pounds of air to burn to CO_2 in the combustion chamber. The temperature reached in this chamber is about 2600 degrees Fahrenheit, and that of the waste gases below the bottom retort about 2000 degrees Fahrenheit.

The heat lost by decomposing the water in the ash pan into H and O is at once regained when the H burns to HO_2 again. The heat losses are caused by excess air drawn in the air passages, by opening the mouth-piece doors, by radiation and the sensible heat of the waste gases escaping into the atmosphere, plus leakage and carbon lost in the ashes. A good recuperative bench has a heat efficiency of about 70 to 72 per cent.

The present greatest obstacles to increasing the efficiency are

*From *The Wisconsin Engineer*, Volume VII, page 96, February, 1903.

the lack of knowledge concerning the specific heat of gases at temperatures varying from 0 degrees to 4000 degrees Fahrenheit, and the difficulty of making accurate high temperature determinations. Le Chatelier's pyrometer is a great help, but to those of us engaged in the gas engineering business, it seems a great pity that some enterprising college professor cannot or will not immortalize himself by determining such coefficients not from purely theoretical considerations alone but also from experiments.

We will now follow the course of the gas as it is made in the retort. The changes taking place in that vessel are many and complex, and leaving that the crude gas passes up the standpipes, across the bridge pipes, and down the dip pipes into the hyraulic main, looking more like nasty yellow smoke than anything else. In the hydraulic main the gas deposits a large percentage of its tar and some ammoniacal liquor, and has attained a temperature of about 150 to 180 degrees Fahrenheit.

From the hydraulic main it is usually conducted through the foul main to the exhauster. These are made in various designs, but the rotary type is probably the best known in this country. They are so governed as to maintain a constant low pressure in the retorts. The exhauster is the heart of the works; it draws the gas from the retorts, pushes it through all the condensing scrubbing and purifying apparatus into the holder, and thus indirectly actuates all the gas meters in the city, which "work while the poor gas man sleeps."

Beyond the exhauster, the first object is to free the gas from the remaining tar. This is done by hot washing, scrubbing, or by mechanical devices such as the Pelouze and Audouin tar extractor, which depends on impact to deposit the tar. After this vessel a condenser is usually placed to cool the gas down to 70 or 90 degrees Fahrenheit.

From here, the most approved way to partially purify the gas is to pass it through one or more scrubbers, where it is thoroughly flushed with crude ammoniacal liquor. Crude gas contains a certain percentage of ammonia, which in the scrubbers unites principally with CO_2, H_2S, CS_2 and C_1, forming ammonium carbonate, sulphide and chloride. The heat developed by these reactions should afterwards be taken from the gas by another condenser.

It is a known but seldom appreciated fact, that were sufficient ammonia present, gas could be entirely purified by scrubbing with ammoniacal liquor, but unfortunately there is only about one-fifth enough ammonia in crude gas to do this.

The gas after leaving the scrubbers, is now colorless and freed from tar and a large part of its ammonia. It then passes into a final scrubber or washer, where the remnants of ammonia are absorbed by fresh water.

The final purification now takes place to rid the gas of all of its H_2S and a portion of the CS_2. In England, where unnecessarily stringent laws prevail, lime is the final purifying agent, since this presents the only practical way to remove all the CS_2 in addition to the H_2S. But in the United States iron oxide is almost universally used. The oxide mixture is usually prepared by adding about twenty-five pounds of rusted castiron borings to a bushel of shavings of pine wood, and a series of large vessels, called purifiers, filled with such a mixture.

Foul oxide does absorb a certain percentage of CS_2, but most of this compound passes on with the gas. The chemistry of the iron oxide purification process can be represented as follows. The foul gas passing through the oxide forms two sulphides of iron as follows:

$$Fe_2O_3,H_2O+3H_2S=Fe_2S_3+4H_2O \text{ and}$$
$$Fe_2O_3,H_2O+3H_2S=2FeS+S+4H_2O.$$

When the material ceases to absorb H_2S, it is taken out of the purifier and spread in layers about twelve inches deep, and thus exposed to the action of the atmosphere. This operation, known as revivification, reconverts the iron sulphides into Fe_2O_3, depositing the sulphur in the free state.

$$2FeS+3O=Fe_2O_3+2S \text{ and}$$
$$Fe_2S_3+3O=Fe_2O_3+3S.$$

After the material is revivified, it is again placed in the purifier, and is thus used over and over again, until the free S forms 40 to 50 per cent. of the mass, when it is no longer fit for use.

The gas, thus finally purified, passes to the station meter to be measured.

WATER GAS MANUFACTURE.

The system of water gas manufacture mostly used today is the Lowe intermittent system. In this method, a generator filled with incandescent carbon (from either coke or coal) is brought to a high heat by an air blast. The resulting producer gas passes on through a vessel called the carburetter, then through a superheater, in both cases being burned in these vessels by an additional blast, thus heating all three vessels, and the waste gases are allowed to escape into the atmosphere. When these vessels have attained the proper temperature the blast is stopped, also the valve allowing the gases to escape to the atmosphere.

Now a steam valve is opened and a large amount of steam is allowed to enter the generator below the fire. Passing up, H_2O vapor is decomposed, the hydrogen passing on unchanged, while the oxygen first unites with the carbon to form CO_2 and this in turn takes on an atom of carbon and becomes CO.

The "blue" gas, consisting of CO and H, passes on to the carburetter, where it meets with a spray of crude oil or gas naphtha, which is vaporized in the highly heated carburetter. The oil is added to make the "blue" gas burn with a luminous flame, in other words, to give it candle power. The lower part of the carburetter and the whole superheater are filled with a checker work of incandescent fire-brick, and the mixed gases passing through this become permanent or "fixed" gas. When during these actions the set has cooled too low for proper gas making, the steam and oil are turned off, and the blast on, until the machines are again hot enough to make gas.

It will thus be seen that this process is an intermittent one, the "blast" periods and "gas making" periods succeeding each other regularly. The gas after leaving the superheater passes through a seal, which prevents it from coming back during blasting, then into a scrubber, then into a tubular water condenser, and finally into a small relief-holder.

From the relief-holder the gas enters an exhauster, which forces it through one or more washers to take out the oil tar. Since oil always contains some sulphur, the gas, after being freed from tar, passes through purifiers where similar reactions take place as in coal gas purifiers. Thence the gas passes to a station meter.

THE STATION METER.

In order to determine the final efficiency of any gas plant, it is necessary to measure the gas made with considerable accuracy. This is best accomplished by the wet station meter, which consists of an outer castiron case, and an inner sheet iron drum. This drum is divided into three or four compartments, so arranged that the gas enters each compartment at one end and leaves at the other end only when the inlet is below the water with which the case is more than half filled. These compartments are accurately measured and their contents computed.

When running, the drum revolves somewhat like a squirrel cage, each compartment in turn receiving its quota of gas from the inlet end, and in turn discharging it to the outlet of the meter. The motion of the drum is communicated to a dial, where the number of cubic feet passing is correctly registered.

Of late years the large wet station meters are being displaced to a small extent by proportional meters, in which the main body of the gas passes through unmeasured, but only a certain small percentage is by-passed and measured. These proportional meters, as they are called, possess the advantage of cheapness, and they have recently been so perfected as to become really reliable instruments. When once they are universally known to be accurate at all speeds, the wet station meter will be a thing of the past.

STORAGE.

The tendency of today is unmistakably to build steel gas holders with steel tanks. Except in very cold climates these holders need not be housed in, and as builders are getting more experience, the holders are becoming structurally more correct. There is apparently no limit to the size which may be attained by these vessels, a twelve million cubic foot holder having been built in London

some years ago. It is rumored that a holder containing twenty million cubic feet is in contemplation in the United States. This will be a veritable monster, the bottom plates of the tank being about two and one-half inches thick, and requiring two and one-half inch rivets. Such a holder will contain many thousand tons of steel, and will be a tremendous structure.

I will not describe holders in this paper, having written an article for the *The Wisconsin Engineer* in the number of January, 1901, on "Steel Gas Holder," to which anyone interested is referred.

PHOTOMETRY AND CALORIMETRY.

The old photometric standard was the British standard sperm candle, burning 120 grains sperm per hour. The standard never was satisfactory, being so variable and having a shade of color different from a gas light. The various other proposed standards are as follows:

(*a.*) The carcel lamp, burning purified colza oil at the rate of 648 grains per hour.

(*b.*) The Hefner-Altenick amyl-acetate lamp, burning with a flame forty millimeters high.

(*c.*) Methven's slot standard, in which a certain portion of a gas flame is visible through a certain sized slot.

(*d.*) Harcourt's pentane standard.

(*e.*) Standardizing against electric incandescent lamps.

The Harcourt pentane lamp, and the electric incandescent lamp are both satisfactory in their way. But photometry is far from being a "solved" problem, inasmuch as we want some instrument that will quickly and correctly give us the mean spherical candle-power.

Calorimetry is assuming more and more importance in the gas business. With the rapid increase of fuel gas uses, it is "heat" that is wanted, not so much high candlepower. It will not be long before the cry will be "More British Thermal Units," and to that end the gas engineers are directing their attention. It goes without saying that "more British Thermal Units for less money" is the correct aim, and it is today one of the things toward which we are looking. Whether the gas shall in itself have a higher calorific value per cubic foot, or whether we shall distribute a fuel gas of lower heat but very cheap, remains for the near future to decide.

SIMPLE TESTS FOR PURITY.

For tar—A piece of clean paper against which a fine stream of gas is allowed to impinge. A brown or dark discoloration will indicate the presence of tar.

For ammonia—A piece of moist reddened litmus or turmeric paper held against a small stream of gas. Turmeric paper turns brown and red litmus paper turns blue in the presence of ammonia.

For H_2S—The gas is allowed to bubble through a solution of lead acetate, which turns brown in the presence of H_2S, owing to the formation of lead sulphide.

For CO_2—A solution of lime or baryta water.

The above are the simple tests usually employed. I am glad to state, however, that gas companies, especially the larger ones, are now employing chemists, especially college men, and we may reasonably expect a large development in the science of gas chemistry within the next few years.

The governor is used to regulate the pressure of gas in the distributing system. In its usual form it consists of a valve or a set of valves, controlled by a float, which in turn is controlled by the pressure on the outlet side of the governor. The holder pressure is usually too large to be used constantly, and the governor allows of regulation according to fluctuations in the demand.

There are various forms of automatic governors on the market which adjust themselves to the demand within certain limits. But there is visibly large space for improvement in this direction.

RESIDUALS.

The residuals usually disposed of at a gas works are coal and oil tar, ammonia and coke. In some of the larger works sulphur and cyanides are recovered.

The uses of coal and oil tar, when made into pitch, tar pavements, roofing felt, paints, varnishes, dyes, etc., are well known and will not be enumerated.

Ammonia, whether anhydrous or aqua ammonia, or as ammonium sulphate, is used largely. Refrigerating plants are now almost wholly dependent upon anhydrous and aqua ammonia. The sulphate is extremely valuable as a fertilizer, and chemically also.

Coke and breeze are now recognized as valuable fuels. The constantly increasing demand for clean screened coke of various sizes, either as coarse, nut or pea, to replace anthracite coal, attest to its popularity.

Sulphur is beginning to be recovered from spent purifying material, and in recent years the development of the cyanide process of gold extraction has caused more attention to be paid to the recovery of the cyanogen of gas. These last two residuals are, however, only extracted in very few gas works in the United States, but a large development will undoubtedly take place in that line also.

In conclusion, I wish to appeal as strongly as I can to the college men who are studying engineering, whether civil, mechanical, mining, electrical, or any other of the numerous special developments of our science. We are living in an age of rapid progress, of constantly widening and broadening views, and of greater and more generous impulses toward each other. The future will see the great body of all engineers laboring in unity, endeavoring to secure the greatest good to the greatest number, and recognized by their fellowmen as the real benefactors of mankind. Therefore I appeal to all to strive to encourage each other, to let each field have its utmost possibilities developed, and by thought word and deed to help your fellow engineer whenever you can.

The gas business, among the rest, is on the verge of a vast revolution, and to those to whom the gift of seeing beyond the pale of ordinary men is given, visions of immense central energy distributing plants arise, from which issue forth streams of gas and electricity that shall light, heat and give power to the universe.

INDUSTRIAL

SOME ENGINE SALES.

THE following is a partial list of engine sales for July, 1903, by Allis-Chalmers Company, Chicago, Ill: Chicago Beach Hotel, Chicago, one 16-inch by 36-inch heavy duty direct connected Reynolds Corliss engine. Knox Construction Company, Chicago, two 20-inch and 40-inch by 48-inch heavy duty cross compound direct connected Reynolds Corliss engine. Richmond Cedar Works, Richmond, Va., one 24-inch and 36-inch by 48-inch heavy duty cross compound Reynolds Corliss engine. Barrett Manufacturing Company, Beloit, Wis., one 20-inch and 40-inch by 48-inch heavy duty cross compound Reynolds Corliss engine. American Aristotype Company, Jamestown, N. Y., one 18-inch by 36-inch girder frame Reynolds Corliss engine. Stilwell-Bierce & Smith-Vaile Co., Dayton, O., one 16-inch by 42-inch girder frame Reynolds Corliss engine. Fourche River Lumber Company, Chicago, one 24-inch by 48-inch heavy duty Reynolds Corliss engine, one 20-inch by 42-inch heavy duty Reynolds Corliss engine. J. I. Case Plow Works, Racine, Wis., one Reynolds air pump and jet condenser. Consumers' Heat and Electric Company, Bloomington, Ill., one 20-inch and 32-inch by 36-inch heavy duty cross compound Reynolds Corliss engine, Union Sugar Company, San Francisco, Cal., one 18-inch by 36-inch girder frame

Reynolds Corliss engine. Canton Oil Mill Company, Canton, Mi.ss, one 16-inch by 42-inch girder frame Reynolds Corliss engine. Henry Du Pont, Wilmington, Del., one 20-inch by 42-inch girder frame Reynolds Corliss engine. Olds Motor Works, Lansing, Mich., one 16-inch by 42-inch girder frame Reynolds Corliss engine. The Clayton Oil Mills, Clayton, N. C., one 18-inch by 42-inch girder frame Reynolds Corliss engine. The Homestake Mining Company, Lead, So. Dak., one 18-32-34-34-inch by 42-inch combined Hor-Vert, triple expansion engine, three 320-horsepower Sederholm boilers. Lacey-Buek Iron Company, Birmingham, Ala., one 44-inch and 84-inch by 60-inch vertical standard furnace blowing engine. C. A. MacDonald, Chicago, one 16-inch by 36-inch girder frame Reynolds Corliss engine, without crank, crank-shaft, wheel, etc. Arkansas City Milling Company, Arkansas City, Kan., one 22-inch by 42-inch heavy duty Reynolds Corliss engine. Manhattan Rubber Manufacturing Company, Passaic, N. J., one 24-inch and 40-inch by 42-inch heavy duty tandem compound Reynolds Corliss engine. Charles B. Pride, Appleton, Wis., one 18-inch by 36-inch heavy duty Reynolds Corliss engine, substituted for 14-inch by 36-inch sold May 25, 1903. Columbus Buckeye Lake and Newark Traction Company, Columbus, O., one 34-inch and 68-inch by 48-inch vertical cross compound condensing heavy duty Reynolds Corliss engine. Lock, Moore & Co., (Ltd.) Westlake, La., one 24-inch by 48-inch heavy duty Reynolds Corliss engine. Georgia Cordage Mills, Decatur, Ga., one 16-inch by 42-inch heavy duty Reynolds Corliss engine. Marquette Cement Manufacturing Company, La Salle, Ill., one 20-inch by 42-inch heavy duty Reynolds Corliss engine. Coe Brass Manufacturing Company, Torrington, Conn., one 22-44-inch by 42-inch and one 19-38-inch by 42-inch combined horizontal and vertical. Compound Reynolds Corliss engine. Two air pumps and two jet condensers. Charles Waite, South Dakota, one 12-inch by 30-inch girder frame Reynolds Corliss engine. Two 70 horsepower 54-inch by 16-feet tubular boilers. One No. 5 feed water heater. The Gauley Company, Camden-on-Gauley, W. Va., one 16 inch by 36-inch heavy duty Reynolds Corliss engine. Rock Hill Water, Light and Power Company, Scranton, Pa., one 20-inch by 42-inch girder frame Reynolds Corliss engine. Memphis Consolidated Gas and Electric Company, Memphis, Tenn., one 27-72-inch by 48 inch horizontal cross compound heavy duty direct coupled Reynolds Corliss engine.

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A SMALL ENGINE-GENERATOR SET.

THE demand for a small engine-generator set for marine purposes and use generally where compactness and low first cost are of more importance than low steam consumption and good fuel economy, has opened a most inviting field for just such an outfit as the one shown herewith. It is the outcome of an arrangement effected between the W. D. Forbes Company, of Hoboken, N. J., the builders of the engine, and the Crocker-Wheeler Company, of Ampere, N. J., whose standard open-type multipolar machine is used for the dynamo end of the unit. The set may be had in various sizes but the particular one illustrated consists of a 7x6-inch simple engine capable of indicating 20-horsepower under 100 pounds of steam when running at 425 revolutions per minute, and a four-pole, No. 20, D type generator having a capacity of eight kilowatts at that speed. Since illuminating is the class of service in which it will meet the most extended use, a more significant conception of its capacity may be conveyed in the statement that it is capable of lighting 140 16-candle-power lamps. Nevertheless it is remarkable for its lightness and compactness, weighing but 2800 pounds, and measuring in extreme dimensions but 52⅝ inches long, 35¼ inches wide and 51¾ inches high.

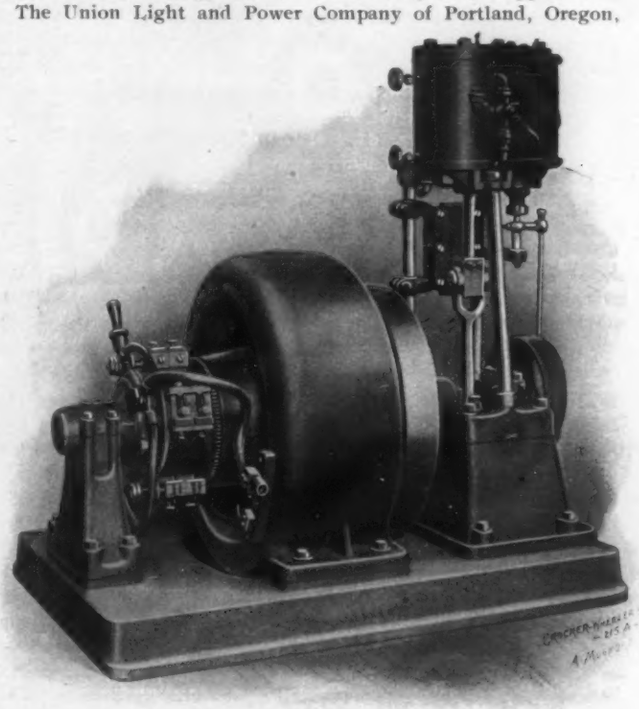
The engine by itself weighs only 475 pounds, this extremely light weight having been secured, without sacrificing strength or rigidity, by employing scientifically correct lines in the design and the best grade of open-hearth steel for the forgings entering into its construction. The crank-shaft is machined from a solid forging, the cross-head and piston-rod are in one piece and there were no welds permitted in any part. The outfit has been produced with special attention to the refinements essential to satisfactory operation. For example, speed regulation is provided by a "Rites" patent inertia governor guaranteed to maintain within 2½ per cent. of constant speed, this being quite close enough to prevent the annoyance of flickering lights. Contrary to the usual custom, the governor is not combined with the fly-wheel, as a reference to the cut will show. This is of advantage, for while the best location of the fly-wheel is between the engine and generator, the governor should be where it is most accessible for adjusting. Although the cut does not show it, a gravity system of lubricating is furnished with the engine whereby all moving parts are kept continuously oiled while the engine is running.

The generator is a compound-wound machine of the open type, there being not the slightest objection to its use in a case of this kind, as it may almost invariably be located where dust, moisture, combustible materials, or the usual conditions prevalent when an enclosed type of machine is demanded, do not exist. By virtue of its open construction, on the other hand, it possesses certain advantages not enioyed by its semi-enclosed or fully-enclosed prototypes. Chief among these are the availability of all of its parts for inspection and repair, and the splendid ventilation afforded to the armature and windings, thus preventing excessive heating even under considerable overload. The entire unit is the result of a most careful design, the component parts are of the highest class of material and the set will be found capable of a steady and reliable service under long periods of continuous full load.

RECENT ALUMINUM ORDERS.

AN aluminum order of note is that of the Portland Railroad Company of Portland, Oregon, for a large quantity of weather-proof feeders for their railway system. These feeders will consist of a quantity of each of the following sizes: 1,564,500 circular mill cable, equivalent in conductivity to 1,000,000 circular mill copper; 782,200 circular mill copper; 331,000 circular mill cable, equivalent in conductivity to 4/0 copper.

The Union Light and Power Company of Portland, Oregon,



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have also an order in for fifty-one miles of No. 4 bare three-strand aluminum wire, equivalent in conductivity to No. 6 copper. In addition to the above new business, the California Central Gas and Electric Company have on order several carloads of 350,000 circular mill bare cable for their extensions in Butte County.

As experience demonstrates more and more the value of aluminum wire as an electrical conductor, orders come in with increasing rapidity. At the present time the factory is taxing its capacity in taking care of the material which is being ordered.

MORE NERST LAMP EQUIPMENTS.

THE Pennsylvania Railroad Company is equipping more of its offices with Nernst lamps, thereby attesting to the superiority of the illumination afforded by this now famous lamp. The Philadelphia office of the Nernst Lamp Company reports that twenty-six six glower and five three-glower Nernst lamps have recently been installed in the freight department of the Pennsylvania Railroad at Broad and Washington Avenues, Philadelphia, this being one of the most important departments of the company.

Several three-glower Nernst lamps have, also, been placed in the power house at Camden, N. J., and the lighting equipment at the new passenger station is about to be completed by the installation of twenty-three lamps of the three-glower type, which will be an addition to the six-glower Nernst lamps already in use.

It is expected that the new shops of the Philadephia, Baltimore and Washington branch of the Pennsylvania Railroad will be largely lighted by this illuminant, the six-glower type being used.

A NEW STORAGE BATTERY CONTRACT.

A. B. Du Pont, vice-president of the St. Louis Transit Company, has recently executed a contract with The Electric Storage Battery Company, of Philadelphia, manufacturer of the "Chloride Accumulator," for the installation of a 3000-kilowatt storage battery to be used in a rotary substation with rotarys having a capacity of 6000 kilowatts. The battery will regulate on the fluctuations and assist in caring for the morning and evening peaks. The substation is in the center of the city, and this installation is one of the extensions being made for the purpose of caring for the increase of traffic. It is interesting to note that this contract represents the largest individual installation of storage batteries in the world for railway service.

SUCCESSOR TO THE OAKLAND IRON WORKS.

THE Oakland Iron Works was succeeded on July 18, 1903, by the United Iron Works. Charles S. Booth, president, R. Winsby, secretary and treasurer. Mr. E. B. Norton, for many years secretary and treasurer of the Oakland Iron Works, has retired from active business and will not be connected with the new corporation. With this exception the change is in name only and the business will be conducted in all respects as heretofore. Accounts prior to July 18th may be remitted to either the Oakland Iron Works or United Iron Works.

REMOVAL OF THE STIRLING COMPANY.

The Stirling Company, Manufacturers of Stirling Water Tube Boilers, general office Pullman Building, Chicago, Ill., has removed its San Francisco office from 330 Market Street to 32 First Street, where larger and better arranged quarters have been provided. The office still remains in charge of Dr. Edgar Kidwell, Pacific Coast manager. R. H. Dalzell, formerly with the Chicago office, has since July 1st been connected with San Francisco office as assistant Pacific Coast manager.

The new marine barracks at the Naval Academy, Annapolis, are to be lighted by electricity, generated by a motor-generator set consisting of a 100 horsepower, direct current motor mounted on the same bed plate with and direct connected to a sixty kilowatt, two-phase alternator. The current will be generated at 1100 volts and transmitted across the river and there transformed to 440 volts. These machines have recently been ordered from the Westinghouse Electric and Manufacturing Company, together with the usual switchboard and auxiliary apparatus.

THE PELTON WATER WHEEL COMPANY.

[COMMUNICATED]

SAN FRANCISCO, September 12, 1903.

To the Editor of The Journal of Electricity, Power and Gas:

SIR—Our attention has been called to one of your recent issues in which appears a note on the subject of the Mill Creek station of the Redlands plant of The Edison Electric Company, near Los Angeles, Cal. The impression that might be produced on a reader of this note is that the Pelton wheel there referred to as in competition with another wheel was lacking in efficiency.

I feel sure that you would not wish your readers to be misled in regard to this point, and therefore take pleasure in stating that the Pelton wheel at the above station showed in efficiency measurements, made by independent engineers, an efficiency of 86.2 per cent, whereas the efficiency of the other type of wheel was materially below this amount. The tests on the latter wheel were conducted by Mr. Samuel Storrer, of the Douglas Building, Los Angeles, and Professor Hoskins. The tests on the Pelton wheel were by Professor Le Conte, of the University of California.

I am authorized by The Edison Electric Company to state that such orders for water wheels as they gave for other than Pelton wheels were placed before competitive measurements of any kind were made on the wheels, and before the plant was put in service operation. We trust that you will do ourselves and your readers the justice to publish these statements so that there may be no misconception in regard to the results obtained by Pelton wheels.

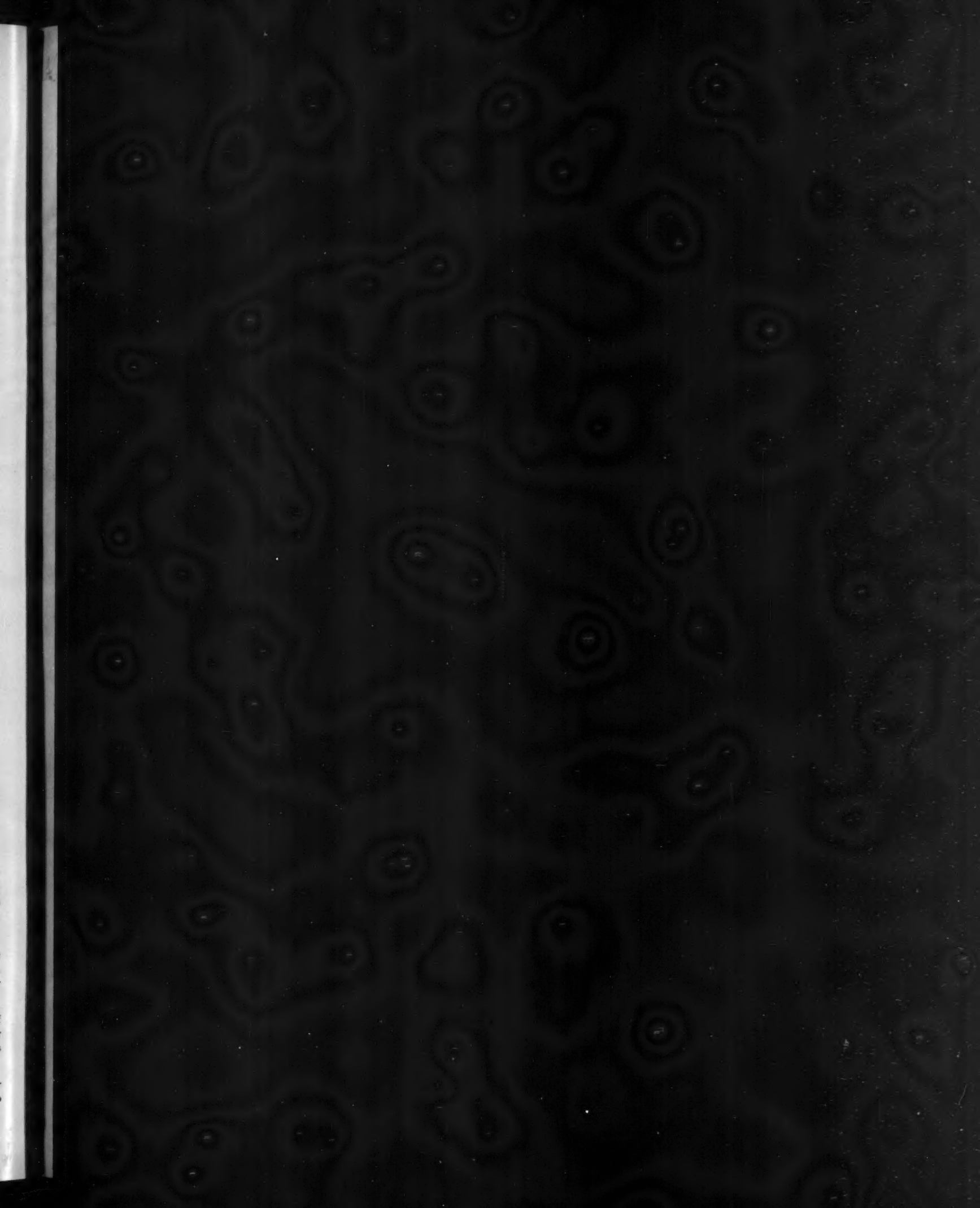
GEO. J. HENRY, JR.
Chief Engineer, Pelton Water Wheel Company.

For the purpose of furnishing current to the arc lamps at the Allouez Ore Docks on Lake Superior, which are the largest iron ore docks in the world, the Great Northern Railway Company has recently purchased from the Westinghouse Electric and Manufacturing Company two seventy-five-kilowatt, 2200-volt, two-phase generators, complete with two 5.62-kilowatt exciters, and a four-panel switchboard. The order also calls for seven 7½-kilowatt and one 2½-kilowatt "O. D." type transformers.

The Los Angeles Railway Company and Pacific Electric Railway Company, of Los Angeles, have each ordered a sufficient number of plates to increase the capacity of their two respective batteries by 100 per cent. Each battery will now have a capacity of 2000 amperes for one hour. These orders were given to the Electric Storage Battery Company, who sold four batteries to these two companies during the early part of the year.

The Canadian General Electric Company, Ltd., Toronto, P. O., Canada, is now representing The Electric Storage Battery Company in the sale of the Chloride Accumulator and the Exide Accumulator throughout Canada, and all inquiries from Canada in regard to storage batteries should be addressed to the Canadian General Electric Company, Ltd.

In a compressed air pumping plant recently installed in the south by the Pneumatic Engineering Company, 128 Broadway, New York, the air lift system pumps 9,000,000 gallons of water per day from four ten-inch wells.

The Kilbourne & Clark Co. have recently sold the University of California one Type H, 4-horsepower, Christensen air compressor for use in the physiological laboratory. This compressor was selected by their engineer on merit only.

The Monterey Gas and Electric Company, have purchased for immediate delivery from the Kilbourn Clarke Company, a 200 kilowatt National Generator for installation in their works.